CO_2 EMISSIONS DYNAMICS

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Abstract

Unlike studies on Environmental Kuznets Curve focusing on the levels of CO_2 emissions, I deal with the dynamics of CO_2 emissions by analyzing their growth rate. Basing on Hausman *et al.* (2005), I develop a filter to identify episodes of CO_2 emissions growth acceleration. In a context of fight against global warming, I also try to identify episodes of CO_2 emissions degrowth. Both filters are composed of three conditions on the level of growth rate, its change and post-episode emissions. I apply these filters on a dataset composed of 124 countries over the period 1950-2004: 285 episodes of growth acceleration are identified and 78 degrowth episodes. I also present a robust econometric analysis explaining those episodes. Note unobserved heterogeneity between nations and endogeneity issue are taken into account in the estimations. Results shows that the Kaya factors are not all significant and influence more the probability of degrowth episodes. Other important explanatory variables are the openness of nations and the growth rate of urban and active population. The estimations do not provide any evidence in favour of a positive effect of national environmental consciousness, despite the increasing awareness of the issue of environmental protection and climate change.

Keywords: growth accelerations, degrowth episodes, carbon dioxide emissions, binomial model, multinomial model, Kaya factors.

JEL Classification: C25, O13, Q53, Q56

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1. Introduction

Based on the hypothesis of the environmental Kuznets curve (Grossman and Krueger 1995), various studies examine the relationship between economic growth and per capita CO_2 emissions (Shafik 1994; Selden and Song 1994; Holtz-Eakin and Selden 1995; Schmalensee *et al.* 1998; Richmond and Kaufmann 2006; Lantz and Feng 2006). However, the idea that the link between income and individual levels of CO_2 emissions can be represented by an inverted-U curve has not been corroborated by those empirical analyses. Indeed, the majority of them show an increasing curve between the level of individual income and CO_2 emissions per capita. Recent papers also stress some econometric problems (Dijkgraaf and Vollebergh 2005; Müller-Fürstenberger and Wagner 2007; Romero-Avila 2008), which weaken empirical results of environmental Kuznets curve studies. Note that these analyses do not provide any precise information on the growth rate of CO_2 emissions since they are mainly interested in the trend of CO_2 emissions according to economic growth. Even so, two papers use their econometric model to provide global annual CO_2 emissions forecasts over the 1986-2100 period (Holtz-Eakin and Selden 1995) and the 1990-2050 period (Schmalensee *et al.* 1998). In a context of acceleration of CO_2 emissions and fight against global warning, information on the growth rate of CO_2 emissions, and so on future emissions levels, is quite essential. Indeed, data on CO_2 emissions from fossil-fuel burning and industrial process shows an acceleration at the global scale, with a growth rate increasing from 1.3% for the period 1990-1999 to more than 3% for 2000-2006 (Canadell *et al.* 2007). This is really worrying since "the emissions growth rate since 2000 was greater than for the most fossil-fuel intensive of the Intergovernmental Panel on Climate Change emissions scenarios developed in the late 1990s" (Raupach *et al.* 2007). In this context, global CO_2 emissions will continue to grow, which will lead to a warming of at least 0.2°C per decade in the next two decades (IPCC 2007). Therefore, the fight against climate change becomes more and more topical in order to limit their negative impacts on ecosystems and health.

Building on the work of Hausmann *et al.* (2005), in this paper, I try to identify national episodes of CO_2 emissions growth acceleration. Note that Hausmann *et al.* (2005) study the existence of growth acceleration of GDP per capita over an unbalanced panel of 106 countries between 1950 and 1999. In this article, the panel is composed of 124 countries over the period 1950-2004. Moreover, as pollutant emissions reductions are important in a context of fight against global warming, I also try to identify episodes of CO_2 emissions degrowth. As far as I know, this is the first attempt to analyze precisely the dynamics of CO_2 emissions in term of growth rate. After having identified episodes of growth accelerations and degrowth, I examine the determinants of those episodes in an econometric model. This second step of the study is essential since it can give some ideas on the drivers of CO_2 emissions accelerations and also on the factors explaining degrowth episodes. The latter is crucial because it could provide some information on the economic, political and institutional conditions that accompany CO_2 emissions reductions. As countries attempt to limit climate change, it can be very useful to know the variables influencing emissions growth better, in order to implement suitable economic or institutional policies.

The plan of the paper is as follows. In section 2, I develop a filter, based on the work of Hausmann *et al.* (2005), to identify the growth acceleration and degrowth episodes and I present empirical results. I also provide a sensitivity analysis of the results to the parameters of the filter. Section 3 deals with the econometric model and the determinants of the growth acceleration and degrowth episodes. Section 4 concludes.

2. Identifying growth acceleration and degrowth episodes

2.1. Methodology

To estimate the timing of growth accelerations and degrowth episodes, I firstly obtain a measure of the average annual per capita CO_2 emissions growth rate between time t and $t+n$, denoted $g_{t,t+n}$. I define this growth rate $g_{t,t+n}$ at time t over horizon n to be the least squares growth rate of CO_2 emissions (E) from t to $t+n$ defined implicitly by the following equation:

$$\ln(E_{t+i}) = a + g_{t,t+n} * i, \qquad i = 0, ..., n. \qquad (1)$$

The change in the growth rate at time *t* is simply the growth over horizon *n* across this period:

$$\Delta g_{t,n} = g_{t,t+n} - g_{t-n,t} \qquad (2)$$

2.1.1. Growth Acceleration episodes

The way in which I identify growth accelerations essentially follows Hausmann *et al.* (2005). However, the filter was adjusted to CO_2 emissions growth dynamics. Basing on Hausman *et al.*'s conditions for a GDP growth acceleration, I identify CO_2 emissions growth accelerations by looking for rapid growth episodes that satisfy the following three conditions:

(i) $g_{t,t+n} \geq 2.75\,\%\ \text{per year}$,

(ii) $\Delta g_{t,n} \geq 2\,\%\ \text{per year}$,

(iii) $E_{t+n} \geq \max\{E_i\}, i \in [t-10; t]$.

As in Hausman *et al.* (2005), I set the relevant time horizon to be eight years (i.e *n=7*).

Note that the first and third conditions differ from those of Hausman *et al.*'s. The first condition requires the level of the growth rate exceeds some threshold to qualify for a growth acceleration. Hausman *et al.* (2005) require that average growth rate must be at least 3.5% during the acceleration episode. This level could be too high for CO_2 emissions since the highest growth rate in the emissions scenarios published in 2000 by the Intergovernmental Panel on Climate Change is 2.75 % (Nakicenovic *et al.* 2000). Therefore, it is relevant to lower the level for absolute growth at 2.75 % to identify more episodes of growth acceleration. The second condition guarantees that the change in pollutant growth rate exceeds a certain threshold, which I assume to be 2 %. Therefore, note that the key element in the filter is the combination of both a high level of growth and a significant acceleration of growth. The last but not the least condition deals with emissions level after a growth acceleration episode. In Hausman *et al.* (2005), this condition requires that post-growth output exceeds all pre-episode peaks. This condition serves to exclude phases of growth simply resulting from economic recovery after a substantial destruction of the economy (wars, natural catastrophes, recession). Applying this condition to CO_2 emissions growth will prevent the identification of some acceleration episodes. For example, if a country experiences rapid growth at the beginning of the period of study followed by a decrease in emissions, a rise of the growth rate at the end of the period will be identified as an acceleration episode only if post-growth emissions are superior to all previous emissions. If post-growth emissions remains smaller than all past emissions, this period will not be qualify as an acceleration episode. Therefore, I used a less stringent filter: in this study, post-growth emissions must be higher than the past ten annual emissions before the initiation of the acceleration.

2.1.2. Degrowth episodes

As I underline in the introduction, identifying periods of decrease in CO_2 emissions, in other words episodes of negative growth, is also interesting in the current context of fight against climate change.

The way in which I identify degrowth episodes is inspired by Hausmann *et al.* (2005) and Arbache and Page (2007) papers. I identify CO_2 emissions degrowth episodes by looking for negative growth periods that satisfy the following three conditions:

(i) $g_{t,t+n} \leq -1\%$ per year,

(ii) $\Delta g_{t,n} \leq -2\%$ per year,

(iii) $E_{t+n} \leq \min\{E_i\}, i \in [t-5; t]$.

As for growth accelerations, I set the relevant time horizon to be eight years (i.e *n=7*).

The first condition requires the level of the growth rate is negative and inferior to -1 %. I chose this threshold to exclude episodes of negative but feeble (and insignificant) level of growth rate. The second condition guarantees that the change in pollutant growth rate is smaller than a certain threshold, which I assume to be -2 %. Therefore, as for acceleration episodes, the key element in the filter is the combination of both a high level of negative growth and a significant reduction of growth. Finally, the third and last condition ensures that post degrowth emissions are inferior to the past five annual emissions before the initiation of the decrease in emissions[1].

[1] Note that the third condition of a degrowth episode is less stringent than the one of an episode of growth acceleration. This adjustment has been developed to identify all significant episodes of negative growth,

Before presenting empirical results, note that if the aforementioned filters show that the three criteria are met in a particular country for a number of consecutive years, I select the start of the growth acceleration (or degrowth episode) by choosing the year for which the F-statistic of a linear spline regression with a break at this year is maximized. More precisely, for all candidate years, $\ln(E_{t+i})$ is regressed on a constant and a trend "broken" at time *t* (for $i=-n, \ldots, n$). The timing of the initiation of the growth acceleration is then selected by finding the maximum F-statistic of a test for equality of the two trend slopes[2].

Finally, countries can have more than one instance of growth acceleration as long as the dates are more than 5 years apart (so a country could accelerate from 0 to 3.5% in 1967 and then accelerate from 3.5 to 6% in 1972 as two distinct episodes).

2.2. Data and Empirical results

2.2.1. Data

Data for CO_2 emissions are taken from Marland *et al.* (2007). This database provides global, regional and national estimations of annual fossil-fuel CO_2 emissions for the period 1751-2003. Fossil-fuel CO_2 emissions include gas, liquid and solid fuels, gas flaring and cement production. Fuel data come from energy statistics published by the United Nations, while data on gas flaring are from the U.S. Department of Energy and cement production from the U.S. Department of Interior's Geological Survey. This database omits natural carbon emissions (eruptions, vegetal, animal and human breathing, organic matter decomposition), representing at most 30 % of total CO_2 emissions. The Marland's database is interesting since it provides emissions data for a relative large number of countries and years computed with the same methodology. In this context, my (balanced) dataset is composed of 124 countries from 1950 to 2004 (cf.

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even if the decrease in CO_2 emissions is not sustained. Indeed, by applying the symmetric third condition (i.e $E_{t+n} \leq \min\{E_i\}, i \in [t-10; t]$), some interesting periods of negative growth were not identified (e.g. Colombia, Kenya, Venezuela).

[2] This methodology was firstly developed by Hausman *et al.* (2005). Other studies on growth accelerations also applied this procedure (Dovern and Nunnenkamp 2007; Jong-A-Ping and De Haan 2008).

appendix 1), representing 92 % of global CO_2 emissions in 2000. Note that my dataset allow me to search for growth accelerations and degrowth episodes for a total of 124 countries during the 41-year period between 1957 and 1997.

2.2.2. CO_2 emissions growth accelerations: First Results

The three conditions of a CO_2 emissions growth acceleration are satisfied by 285 episodes. Aside from the important number of accelerations, the magnitude of the average acceleration is also interesting. Conditional on a growth acceleration of at least 2 ppa, the average acceleration is 10.14 % (median 8.68 %).

I estimate the (unconditional) probability of an emission growth acceleration by dividing the number of episode (285) by the number of country-years in which an episode could have occurred (3944). The latter is computed by summing up all the country-years in our sample and eliminating a 4-year window after the occurrence of each episode, since my filter takes the period as belonging to the same episode (3944=124*41-285*4). Therefore, the average probability of a growth transition is our sample is about 7.23 % per year. This means that a country would have more than 85 % chance of experiencing a growth acceleration at some point in any given decade.

The proportion of countries that experience at least one growth acceleration also underlines the high rate of occurrence of such growth episode. Over my sample, 114 countries (or 91.13 %) have experienced at least one growth acceleration, 87 (or 70.16%) two and more, and 61 (or 49.19 %) three and more accelerations.

Table 1 presents the number and probability of growth accelerations by region and decade. Nevertheless, note the decades of the 1950s and 1990s have fewer observations than the thirty intervening years. In the case of the 1950s, the reason is the lack of pre-transition growth rates, which means my first feasible date is 1957. As for the 1990s, the absence is due to the fact that my filter requires the calculation of post-transition growth rates, as so my last feasible date is 1997.

With these limits on the 1950s and 1990s, the probability of a growth acceleration was important during the 1960s and 1980s but declined in the 1970s and 1990s. When looking by regions, the largest number of growth acceleration is in Latin America, but the highest probability of such an episode appears in Middle East countries. With over-average probabilities of a growth acceleration, Africa and Asia follow Middle East and Latin America. Note that the probability of a growth acceleration in Asia and Middle East was the largest during the 1980s. Finally, other countries, North America and Europe have the lowest probabilities of a growth acceleration, 6.61 %, 6.06 % and 3.65 % respectively.

Table 1: Probability of a growth acceleration per region and decade

	Asia	Africa	Middle	Europe	Latin America	North America	Other	Total (%)	Epi-sodes	Obser-vations
1950s	15.38	13.21	28.57	11.11	13.11	50	15.4	14.41	34	236
1960s	8.65	13.79	6.25	6.25	13.37	16.7	11.5	10.39	91	876
1970s	4.17	5.96	6.25	1.21	3.28	0	3.2	3.70	40	1080
1980s	11.46	6.54	16.67	3.51	10.55	6.3	7.4	7.84	74	944
1990s	4.17	10.53	6.25	2.08	7.98	0	3	5.69	46	808
Total -%	7.47	9.12	9.39	3.65	8.69	6.06	6.61	7.23	285	3944
Episodes	33	74	28	34	82	4	30	285		
Obs.	442	811	298	930	943	66	454	3944		

Note: Number of growth episodes divided by number of valid datapoints in that decade and region.

To know whether episodes of rapid growth were sustained, growth rates starting eight years after the initiation of the episode are examined. Table 2 presents the growth acceleration episodes by their growth rate in the seven years preceding the increase in emissions ($g_{t-7,t}$) and in the seven years following their episode of rapid growth ($g_{t+7,t+14}$)[3]. To classify the remaining 243 episodes, I choose to distinguish between negative and (slow and rapid) positive growth.

After the end of the episode, 150 had positive rapid growth, 50 slow growth and 43 negative growth rates. In other words, 61.7 % of episodes were sustained into the longer term by rapid growth and 20.6 % by slow growth. Therefore, the majority of growth accelerations continue with an increase in CO_2 emissions. Indeed, only 17.7 % of episodes were followed by negative growth, and so a decrease in CO_2 emissions. By looking at results by regions, note that more than 70 % of episodes are sustained in Asia and Africa whereas in Europe and other countries, respectively 58 % and 50 % of episodes, are followed by rapid growth.

[3] Since post-acceleration episodes growth rates are needed, some episodes are lost. In this part of the article, no episode can occur after 1990.

Table 2: Episodes of rapid growth classified by growth rate before and after the episode

		Growth rate <u>before</u> the episode: $g_{t-7,t}$		
		Negative Growth	Positive Growth: Slow $[0; 2.75]$	Positive Growth: Rapid >2.75
Growth rate <u>after</u> the episode: $g_{t+7,t+14}$	Negative Growth	BER82 DEN89 GIB73 ICE72 KUW77 LUX85 MOZ67 SLA76 VEN63	BAR84 BRU64 EGY57 KEN70 MYA78 SAL70 SAU87 SLA64 SPM84	AUT67 BAH69 BER68 BOL90 BRU69 CAM75 CPV72 CZE75 ECU75 GUT71 IRA72 LEB67 LYB63 MAL85 MAR67 MEX74 MON84 NWZ69 PAR90 SIE63 SVG65 SUD64 SWE62 UGA62 VEN88
	Positive Growth: Slow $[0; 2.75]$	BLZ84 ECU89 ICE83 JAM88 JAP85 NWC63 NWZ81 ZAI62	ANG89 ARG64 AUS86 CAN63-89 CPV67 CZE58 EQU82 FIJ76 FGU83 IRE84 ISR81 KOR82 MAL62 MEX87 MOR86 MYA65 TTO69 USA62	ALG69-81 BAR62 CUB69 DJI78 DOM66-90 FGU88 GAM75 GRN65 HAI73 IRE66 JOR77 KOR87 NOR62-74 PAR72 SAL89 SLU63 SAM74 SAF78 TOG74 TON87
	Positive Growth: Rapid >2.75	BHR57-68 BOL85 BRA84 BRU59 CPV62 CHL87 CSR84 CUB64 DOM81 EGY71 EQU71 ESP85 GIB84 GRN76 GUT85 HAI68 HON86 IRA82 IRE58 IRN83 KEN87 LEB80 MAR80 MAU63-80 PAN87 PHI86 QUA62-87 SAL84 SAU57 SLA89 VEN75	ALG64 BOL62 CAM64 CAN58 CHL82 CHN64 CSR59 CYP86 DEN59 DJI71 FAO63 GHA69-87 GRN58 HAI63 IDN66 JOR72 MAL79 MAU85 MOR61 NIC88 PAR85 POR88 REU85 SLU86 SLA59 SVG59-78 SUD85 TAI87 TON59-69 TTO60 TUN62-74	ALB66 ANG61 BAH58 BLZ61 BRA67 BUL58 CSR64-89 CHL58 CHN69-82 CYP64 DJI59 DOM61 ECU63 ESP64 FIJ58-63 FIN62 FGU61-75 GHA64 GIB89 GAM65 GRE57-62 GRN83 GUA57-74 GUY59-64 HON67 HGH58 IND72 IDN71-84-89 IRA64 IRN89 ISR59-88 ITA60 JAP59 KUW83-90 LEB87 LIB57 LYB58 MAD61 MAL74 MAR62 MEX66 MON73 MOR67 NET58 NIG59-67 PAN57-64 PAP64 PER59 PHI61 QUA57 REU61-72 SAL62 SAM69 SAU66 SLU58 SVG83 SUR61 SWI58 SYR75 THA61-85 TOG59 TON64 TUN57 TUR61-80 URU83

2.2.3. CO_2 emissions degrowth episodes: First Results

Concerning periods of negative CO_2 emissions growth rate, only 78 episodes satisfy the three conditions of a degrowth episode. Note that conditional on a growth reduction of at least 2 ppa, the average decrease is -6.7 % (median -5.4 %).

Even if the number of degrowth episode is significantly smaller than the one of growth accelerations, nearly half of the countries in the sample experience a reduction in CO_2 emissions during the period 1950-2004, precisely 59 countries representing 47.48 % of the total dataset.

As for growth acceleration episodes, I also estimate the (unconditional) probability of an emission degrowth episode by dividing the number of episode (78) by the number of country-years in which an episode could have occurred (4772=124*41-4*78). Therefore, the average probability of a degrowth transition is our sample is about 1.63% per year. This means that a country would have around 15 % chance of experiencing a reduction in CO_2 emissions at some point in any given decade.

Table 3 presents the number and probability of negative growth by region and decade. Remind that results for the decades 1950s and 1990s are limited given their small numbers of observations.

Table 3: Probability of a degrowth episode per region and decade

	Asia	Africa	Middle	Europe	Latin America	North America	Other	Total (%)	Epi-sodes	Obser-vations
1950s	0	2.74	3.85	0	0	0	0	0.83	3	360
1960s	0	0.38	1.04	0	0.33	0	16.67	0.33	4	1224
1970s	1.52	3.85	0	4.02	2.10	6.25	3.22	2.78	31	1116
1980s	0.74	2.89	1.04	4.02	1.72	0	1.51	2.19	25	1140
1990s	3.00	0.47	0	3.89	1.27	0	0.92	1.53	15	932
Total-%	1.09	1.95	0.76	2.59	1.24	1.28	1.48	1.63		
Episodes	6	20	3	25	15	1	8	78		
Obs.	550	1027	394	966	1210	78	542	4772		

Note: Number of degrowth episodes divided by number of valid datapoints in that decade and region.

The most striking results is that the probability of a degrowth episode is the highest during the 1970s and 1980s. During those two decades, a country would have more than 20 % chance of experiencing a degrowth period. Looking at the experience by regions, Europe and Africa are the regions with the largest probability of negative growth, 2.59 % and 1.95 % respectively. Note that those episodes of CO_2 emissions reductions began in the 1970s for Europe and were concentrated in the 1970s and 1980s for Africa. Concerning Europe, my results shows an interesting result: it is the region experiencing the smallest probability of growth acceleration but the highest probability of a degrowth period.

Table 4: Episodes of negative growth classified by growth rate before and after the episode

Growth rate <u>after</u> the degrowth episode: $g_{t+7,t+14}$		Growth rate <u>before</u> the degrowth episode: $g_{t-7,t}$ — Negative < -2 %	Negative $]0,-2]$	Positive ≥ 0
Negative	< -2 %		POL89 SWE77	ALB85 BAH75 BUL85 CUB86 GIB69 LIB76-81 LUX71 MOZ74 ROM86 ZAI88
Negative	$]0,-2]$		ANG87 BEL77 BUL90 CZE87 DEN77 GUY76 HUN85 POL84 SPM71	GER88 NIG84 PER78 USR88
Positive ≥ 0		MOZ79	BAH80 GIB78 LUX76 URU78	ALB90 AUT76 BHR59 BOL81 BRU75 CAM83 CPV76 EQU59 FIJ80 FIN77 FRA78 GRL69 GUY81 HAI87 JAM79 KEN79 KUW68-85 LIB89 MAD76 MYA83 NET77 NOR85 NWC74 PAN78 PHI78 SAL77 SIE83 SUD74 SUR77 USA76 UGA72 VEN69 ZAI57

Note that the filter does not distinguish between temporary and sustained reductions in CO_2 emissions. In order to examine whether or not degrowth episodes are sustained, as for growth acceleration episodes, I look at growth rates starting eight years after the initiation of the episode. Table 4 presents the degrowth episodes by their growth rate in the seven years preceding the decrease in emissions ($g_{t-7,t}$) and in the seven years following their episode of degrowth ($g_{t+7,t+14}$)[4]. To classify the remaining 65 episodes, I choose to distinguish between (slow and rapid) negative and positive growth rates. After the end of the episode, 39 had positive growth rates and 26 negative (13 between 0 and 2 % and the other half superior to 2 %). Therefore, 40 % of the identified episodes of degrowth are sustained but 60 % are temporary. As can be seen, European countries represent 50% of sustained degrowth episodes and only 18 % of temporary episodes.

[4] Since post degrowth episodes growth rates are needed, some episodes are lost. In this part of the article, no episode can occur after 1990.

2.3. Sensitivity analysis

Before launching into further analysis of the drivers of (de)growth episodes, a discussion on the definition of a (de)growth episode, particularly the various parameters, is developed. Indeed, concerning growth acceleration, using an 8-year period and the thresholds of 2.75 % growth and a 2 ppa increase are defensible, but admittedly arbitrary. This is the same with the definition of a negative growth episode. Therefore, it is necessary to study the effects of the variation of the parameters of the filter to assess the robustness of the method. The expected effects on the number of identified episodes are summed up in Table 5.

Table 5: Expected effects of the variation of the filter parameters on the number of episodes

Variation of the parameter	Growth Acceleration episodes	Degrowth episodes
Tightening the growth threshold ($g_{t,t+n}$)	Decrease	
Tightening the acceleration/reduction threshold (Δg)	Decrease	
Relaxing the acceleration/reduction threshold (Δg)	Increase	
Shortening the time horizon (n)	Increase	

Tightening or relaxing the thresholds of the filter produces the expected aforementioned results, as shown in Appendix 2. If the threshold for change is (-) 2 ppa but the (negative) growth threshold is raised (decreased) to 3.5 (-2) %, then 277 (69) episodes are identified versus 285 (78). With the thresholds for absolute (negative) growth at 2.75 (-1) %, increasing the acceleration (reduction) threshold to 3 % yields 237 episodes while relaxing it to 1 % (0 %) identifies 346 (88) episodes. It is also obvious that shortening the time window, for which the average growth are calculated, from 8 to 5 years leads to a significant rise in the number of identified episodes: ceteris paribus, 490 versus 285 for growth accelerations and 107 versus 78 for degrowth episodes. Yet, note that although variations of the filter parameters have an effect on the number of episodes, they influence very slightly the various features (average, median…), especially for degrowth episodes.

3. Determinants of growth accelerations and degrowth episodes

In this section, I develop an econometric model to analyze the probability of a CO_2 emissions growth acceleration/degrowth episode. The model is the following:

$$Y_{it}^{*} = \beta' X_{it} + \varepsilon_{it}, i = 1, ..., N \; t = 1, ..., T \qquad \textbf{(3)}$$

where the underlying latent variable, Y_{it}^{*}, can be interpreted as the trend of a country to experiment an episode of CO_2 emissions growth acceleration/degrowth.

Let Y_{it} $\begin{cases} = 1 \text{ if country } i \text{ experiments an episode of acceleration/degrowth} \\ = 0 \text{ otherwise.} \end{cases}$

Therefore, $Y_{it} = 1$ when $Y_{it}^{*} > 0$ et $Y_{it} = 0$ when $Y_{it}^{*} \leq 0$. In equation **(3)**, index *i* represents the country and index *t* the year, with N the total number of countries in the sample and T the total number of years. X_{it} is the set of exogenous explanatory variables specific to a country and/or to a year, β is the vector of associated parameters and ε_{it} is the residual term.

Note that after the identification step, the dataset is composed of 124 countries over 41 years (1957-1997). This sample has been adjusted for the econometric analysis[5]. Firstly, as there is some uncertainty on the timing of an acceleration/degrowth episode, in the case of such an episode occurs at time *t*, the dependent variable takes the value 1 for the dates *t-1, t, t+1*. Moreover, I drop all data pertaining to years *t+2* to *t+7* of an episode, as I am interested in predicting the timing of accelerations and degrowth episodes.

I would like to underline that four different econometric models have been developed. I present firstly empirical results from pooling regressions (section 3.2). Then, I improve the econometric analysis by taking into account heterogeneity (section

[5] In this context, I follow the methodology developed by Hausman *et al.* (2005) and used by Jong-A-Pin and De Haan (2007, 2008) and by Dovern and Nunnenkamp (2007).

3.3) and I also test the exogeneity assumption for an explanatory variable (section 3.4). In the last sub-section, I extend the study by estimating a multinomial response model (section 3.5). Before presenting the econometric methodologies and results, I begin by describing the explanatory variables in the next sub-section.

3.1 Explanatory Variables: Definitions and Data

I categorize the explanatory variables, X_{it} in equation **(3)**, under four headings:

(i) The Kaya factors.

The Kaya identity (1989, Yamaji *et al.* 1991) is the traditional analytical tool used to analyze the determinants of CO_2 emissions. More precisely, according to the Kaya equation, CO_2 emissions are decomposed in a product of four elements: population, gross domestic product per capita, energy intensity of GDP and carbon intensity of energy. For this econometric work, I do not use the Kaya identity in level but in growth rate since conditions for an acceleration/degrowth episode clearly refers to growth rate. Therefore, four explanatory variables are taken into account: the growth rates of population, of GDP per capita, of the energy intensity of GDP and of the carbon intensity of energy.

Data on population and GDP are taken from the Maddison's database (2008), except for 6 countries[6] for which information are provided by the dataset of the "Conference Board and Groningen growth and development centre" (2008). Data on national CO_2 emissions are taken from the Marland *et al.*'s database. To compute the energy intensity of GDP, the carbon intensity of energy and their growth rates, unfortunately, I have not found data on primary energy consumption for all the 124 countries over 1957-1997. I used three different data sources[7] defining three sub-samples (cf. appendix 3 for a description of the three datasets). The first provides information on total primary energy consumption for 48 countries from 1965 to 1997

[6] Barbados, Dominican Republic, Cyprus, Luxembourg, Malta et Saint Lucia.

[7] Note that the three datasets are not based on the same definition of primary energy consumption. Data from British Petroleum only take into account traded fuels whereas information from the Energy Information Administration and the World Bank also integrate consumption from wind, solar and geothermal energies.

(British Petroleum, 2008) whereas the second gives data for 76 countries between 1971 and 1997 (World Bank, 2007). Information from the last dataset is available for 83 nations between 1980 and 1991 (Energy Information Administration, 2005).

In order to complete the analysis, I change two Kaya factors to find more precise determinants of acceleration or degrowth episodes. First of all, I replace the growth rate of GDP per capita by the growth rates of the value added per inhabitant of the three main sectors (agriculture, industry and services). Indeed, if economic growth can have an impact on the timing of a episode, it would be interesting to know which sector(s) is(are) behind this effect. Data on sectorial value added (in proportion of GDP) come from the World Bank (2007). Then, following the idea of York *et al.* (2003) and Cole and Neumayer (2004), I use additional demographic variables. I replace the growth rate of population by the one of urban population. The idea is that a higher urbanization rate is likely to have a positive effect on CO_2 emissions "due to the typically more pollution intensive behavioural patterns in urban areas". I also take into account the age structure of the population. The intuition is that the active population (between 15- 64) is likely to have a higher impact on emissions than the retired population (65 and more) and than the children and adolescents (below 15). Data on urban population and the structure of the population come from the World Bank (2007).

(ii) Openness.

An important factor associated to pollution and environmental degradation is international trade, and so openness of nations. However, free trade has contradictory impacts on environment, both increasing pollution and motivating reductions in it. Indeed, on one hand, trade leads to increase in the size of the economy that raises pollution (through the well-known scale effect). On the other hand, trade can make easier specialization and technical transfers between nations, leading to less polluting production methods. In this context, the effect of openness on the timing of episodes of acceleration/degrowth is unclear. Nevertheless, I expect that the scale effect is higher that the composition and technique effects. So, openness is likely to have a positive impact on acceleration growth episodes and a negative one on degrowth episodes.

Two measures of openness have been used. The first is the openness ratio which is the sum of exportations and importations divided by GDP. Data on exchanges come from the online World Trade Organization Statistics Database (2008). The second measure is a binary variable taking the value 1 when country *i* is open. This index has been created by Sachs and Warner (1995) and updated by Wacziarg & Welch (2003). Openness is met when none of five conditions is validated. The conditions deals with non-tariffs barriers, tariff rates, black market exchange rate, type of economic regime and monopoly state on exports, which provide a more exhaustive view of openness than the first measure.

(iii) Oil price.

In the estimations, I search if the growth rate of the oil price has an influence on the timing of an episode. It is possible that a rising price will lead to substitutions between energies as oil becomes more and more expensive. In this context, the growth rate of the oil price would have a negative impact on CO_2 emissions, and so on the timing of an acceleration episode. Concerning degrowth episode, it is likely that a rising oil price enables to slow CO_2 emissions growth but it would not reverse the trend. Therefore, I do not expect the oil price growth rate to have an effect on the timing of a degrowth episode. Data on oil price are taken from British Petroleum (2008).

(iv) Environmental consciousness.

The last but not the least category is composed of variables describing the environmental consciousness of nations. Firstly, I create a binary variable for the ratification of the Kyoto Protocol, taking the value 1 when country *i* signs the protocol. Then, I distinguish between countries belonging to the Annex I, *i.e* countries having agreed to cap emissions, and countries belonging to the non-Annex I, *i.e* countries without emissions reductions targets but vulnerable to climate change. Information needed was taken from the UNFCC website (United Nations Framework Convention on Climate Change). Finally, I add a variable representing the increasing awareness of climate warming. To create this variable, I take a census of the major events which have highlighted the issue of environmental protection and climate change. I take into account nine events: the Earth Summit in Stockholm and the report "Limits to Growth" (1972), the 1st conference of United Nations on Climate Change (1979), the Brundtland Report (1987), the 2nd conference of United Nations on Climate Change (1989), the 1st report of the Intergovernmental Panel on Climate Change (1990), the 1st Earth Summit (1992), the 1st Conference of Parties (1995), the 2nd Conference of Parties (1996), the 3rd conference of United Nations on Climate Change and the 2nd Earth Summit (1997). I code the variable in the following way: it begins at the value 0 and I add *+ 1* if such an event occurs at time *t*. Therefore, the variable remains at 0 up to 1971, becomes 1 between 1972 and 1978, 2 between 1979 and 1986, and so on. Note that this variable is the same for all countries, which is a drawback since nations are not likely to share the same environmental consciousness. Moreover, there is a gap between awareness and change in behaviours. In this context, it is likely that environmental consciousness slows CO_2 emissions growth, and so has a negative impact on acceleration growth episodes but no significant effect on degrowth episodes. To sum up, this variable is an original, yet imperfect, measure of environmental awareness of the whole world.

A table in appendix sums up explanatory variables, their names in the estimations, sources and expected effects on the timing of accelerations growth and degrowth episodes (cf. appendix 4).

3.2 Empirical results for pooling regressions

3.2.1. CO_2 growth acceleration episodes

In this sub-section, let the theoretical econometric model be:

$$Y_{it}^{*} = \beta' X_{it} + \varepsilon_{it}, \; i = 1, ..., N \; t = 1, ..., T \qquad \textbf{(4)}$$

where the underlying latent variable, Y_{it}^{*}, can be interpreted as the trend of a country to experiment an episode of CO_2 emissions growth acceleration.

Let Y_{it} = 1 if country *i* experiments an episode of growth acceleration (when $Y_{it}^{*} > 0$).
= 0 otherwise (when $Y_{it}^{*} \leq 0$)

In this sub-section, note that specific-country effects, describing the unobserved heterogeneity between nations, are not integrated into the analysis. At this step of the paper, I also assume that there is no endogeneity problem, especially on the GDP per capita growth rate.

In this context, I realize the standard Probit[8] estimation over the whole dataset by the maximum likelihood method. Consequently, the random term, ε_{it}, is assumed to follow a normal distribution with a null mean and a unit variance. Results of the estimations for the three sub-samples, according to the source of data of primary energy consumption, are in appendix (appendix 5, tables 5.1 to 5.3) and are expressed in terms of average partial effects[9].

The baseline specification, shown in column (1), includes the four Kaya factors in growth rates. Note that empirical results differ according to the dataset. However, the growth rate of the energy intensity of GDP is the only Kaya factor with statistically significant coefficients in the three samples and has the expected positive effect. This baseline specification is present in all the estimations (columns (2) to (6c)). In this context, note that the growth rate of the energy intensity of GDP is also significant in the majority of the regressions. As for the growth rate of GDP per capita, this variable is significant over the shorter samples (cf. table 5.2 and 5.3) and has the expected positive effect. In the next column, I replace the growth rate of GDP per capita by the three sectorial variables. Unfortunately, this modification is not relevant as a Wald test shows that explanatory variables in a whole are not significant to explain the probability of an acceleration growth episode. In columns (3a) and (3b), I test the effect of the openness of nations. Note that the first continuous variable, the openness ratio, is not significant contrary to the binary index of Sachs and Warner. The latter is significant in samples 2 and 3 and had a positive effect (cf. table 5.2 and 5.3). In this context, the openness of a nation leads to an increase in the probability of experiencing an acceleration growth episode. In the following regressions, I keep the openness variable when it was significant. Note that it remains significant in all models.

[8] The choice of the Probit estimator for the pooling regression is linked to the econometric extensions applied to this paper. Indeed, to take into account the unobserved heterogeneity, I choose to model specific country effects as random effects and so use a Probit estimator with random effects. Moreover, I am also testing the endogeneity of the growth rate of GDP per capita and so use the two-stage Probit estimator, method developed by Rivers and Yuong (1989). In this context, I prefer to use a homogeneous methodology all over the econometric work.

[9] Note that current applied research has many applications based, instead of marginal effects at the sample mean, on "average partial effects" (Wooldridge, 2002). The latter is the mean of all marginal effects computed for each observation in the dataset. Therefore, it provides the average effect of a partial change in one explanatory variable on the probability of success ($P(Y_{it}=1)$). The formula for computing average partial effects of a partial change in the k^{th} explanatory variable, X_k, is the following:

$$\bar{\delta}_k = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\frac{\partial \, \mathrm{Prob}(Y_{it}=1|X_{it})}{\partial X_{kit}}$$

Then, I replace the growth rate of population by more precise demographic variables. In column (4a), I use the growth rate of urban population, which is significant and has a positive average partial effect in the three sub-samples. I also use the structure by age of the population (column (4b)). The most significant variable is the growth rate of the active population. Note that the coefficient is positive, as expected, but also is surprisingly high. This value suggests that the relation between the probability of an acceleration episode and the growth rate of active population is very non linear. This idea is corroborated by the analysis of the graph representing the predicted probability and the growth rate of active population (cf. appendix 6). Indeed, looking at this graph, it is clear that a partial change in the growth rate leads to important positive or negative variations of the predicted probability. In this context, the interpretation of the numerical value of average partial effects can be misleading. Therefore, it is preferable to base conclusions only the sign of the marginal effect. To continue the estimations, I choose to keep these three demographic variables. Column (5) shows the results of the estimation with the growth rate of oil price. For the three sub-samples, this variable is not significant. To finish, I analyze the effect of the variables describing the environmental consciousness. The ratification of the Kyoto protocol appears to be a significant variable over the three dataset (column (6a)) and more precisely the membership to the Annex-I of the protocol (column (6b)). Unfortunately, the coefficients are positive whereas I expect them to be negative. In this context, the ratification of the Kyoto protocol does not seem to be linked to slower emissions growth. On the contrary, it is likely to raise the probability of an acceleration growth emissions. The same contradictory effect appears with the variable representing the global environmental consciousness (column (6c)) over samples 1 and 2.

To sum up, the growth rates of GDP per capita, of energy intensity of GDP, of urban population, of active population and the openness of nations are significant variables influencing positively the probability of a CO_2 acceleration growth episode.

3.2.2. Empirical Results for CO_2 degrowth episodes

As for accelerations growth episodes, the binomial model is estimated by the Probit methodology. The theoretical econometric model is unchanged (cf. equation **(4)**) but, in this sub-section, the underlying latent variable, Y_{it}^*, can be interpreted as the trend of a country to experiment an episode of CO_2 emissions degrowth.

$$\text{Let } Y_{it} \begin{cases} = 1 \text{ if country } i \text{ experiments an episode of degrowth (when } Y_{it}^* > 0). \\ = 0 \text{ otherwise (when } Y_{it}^* \leq 0) \end{cases}$$

Results of the estimations for the three sub-samples, according to the source of data of primary energy consumption, are in appendix (appendix 7, tables 7.1 to 7.3) and are expressed in terms of average partial effects.

I follow the same procedure as for acceleration growth episodes. I begin with the baseline specification with the four Kaya factors in growth rate. The striking result is that the Kaya factors are significant and have the negative expected coefficients, except for the growth rate of carbon intensity of energy. Compared to the acceleration episodes' results, the Kaya factors are likely to have a substantial influence on the probability of a degrowth episode. This baseline specification is present in all the estimations (columns (2) to (6c)). In this context, note that the three first Kaya factors are also significant in almost all the regressions. In column (2), I replace the growth rate of GDP per capita by the three sectorial variables. The interesting finding is that the growth rate of the per capita value added in industry is a significant variable and has a negative effect in the three datasets. Then, in columns (3a) and (3b), I test the effect of the openness of nations. As for acceleration episodes' results, the first continuous variable, the openness ratio, is not significant contrary to the binary index of Sachs and Warner. The latter is significant in all samples and had the expected negative effect. Therefore, the openness of a nation leads to a decrease in the probability of experiencing an episode of CO_2 emissions reduction. Then, I replace the growth rate of population by more precise demographic variables. In column (4a), I use the growth rate of urban population, which is significant and has a negative average partial effect in the three datasets. I also use the structure by age of the population (column (4b)). The growth rate of the active population is the most significant variable. Note that the coefficient is negative, as expected. Therefore, the probability of a degrowth episode will decrease after a partial increase in the growth rate of active population. Column (5) shows the results of the estimation with the oil price growth rate. For the three sub-samples, this variable is not significant, like acceleration episodes' results. To finish, I analyze the effect of the variables representing the environmental consciousness. Over samples 1 and 2 (cf. tables 7.1 and 7.2), variables describing the membership to the Kyoto protocol are not significant. Note that the benchmark situation is different in sample 3 as countries which have not sign the Kyoto protocol did not experience a degrowth episode over the temporal dataset. In this context, I drop these four countries and analyze the effect of the membership to Annex-I of the Kyoto protocol (cf. table 7.3). The reference situation is here the members of the non-Annex-I. Empirical results show a significant and negative effect. This is quite surprising as I expect the membership to Annex-I, i.e the agreement to cap CO_2 emissions, to have a positive effect on the probability of a degrowth episode. It seems that such countries have not already implement policies leading to a reduction of CO_2 emissions. This result questions the success in achieving the Kyoto's targets in terms of CO_2 emissions reductions. As for the variable representing the global environmental consciousness (column (6c)), it is not significant, except in sample 2 and has a striking negative effect.

In a nutshell, the probability of a CO_2 degrowth episode is significantly and negatively linked to the growth rates of three Kaya factors (GDP per capita, population, energy intensity of GDP), more precisely to the growth rate of the urban and active population and to the openness of nations.

3.3 Taking into Account Heterogeneity

The interest of my database lies in the existence of various annual observations for each country. So, it is possible to control for unobserved heterogeneity by integrating fixed or random country-effects. The idea is the following: it may exist some variables specific to each country, unobserved by the econometrician, but having an influence on pollutant emissions dynamics. These unobserved features are likely to biase previous results from pooling regressions. Consequently, my data enable to obtain unbiaised estimators by using individual effects by nations, as for traditional panel data regressions.

Two specifications for specific country effects can be implemented: either fixed or random effects. In this context, the model, represented by equation **(4)**, becomes the following:

- with fixed effects: $Y_{it}^{*} = \alpha_i + \beta' X_{it} + \upsilon_{it}, i = 1, ..., N \; t = 1, ..., T$ **(5)**

- with random effects: $Y_{it}^{*} = \beta' X_{it} + \mu_i + \upsilon_{it}, i = 1, ..., N \; t = 1, ..., T$ **(6)**

In equation **(5)**, α_i represents a parameter specific to country *i*. This effect can be estimated and correlated to explanatory variables, X_{it}. On the contrary, in equation **(6)**, μ_i is a random error term specific to country *i* but independent of exogenous explanatory variables, X_{it}. In this article, the random effects model is preferred to the fixed effects model for two reasons. Firstly, note that the conditional logit estimator with fixed effects, developed by Chamberlain (1980), takes into account countries which have already experienced one episode of acceleration growth/degrowth only. In this context, information from countries which have not known such an episode is not integrated into the estimation, whereas all countries are present in the random-effects probit regression (Wooldridge, 2002). Secondly, unvarying variables over time are dropped of the estimation with a fixed-effects logit regressor. Therefore, it is not possible to estimate the influence of the ratification of the Kyoto Protocol, and the type of membership, on CO_2 emissions dynamics. This is not the case with a random-effects probit model. Nevertheless, even if the random-effects probit estimator has attractive features, it lies on the assumption of independence between country-effect and explanatory variables[10], contrary to the conditional fixed effects logit. It is a strong assumption but, contrary to linear models it can't be tested by a Hausman test since residuals from both estimations do not follow the same distribution.

3.3.1. CO_2 growth acceleration episodes

In this sub-section, let the underlying latent variable, Y_{it}^{*}, be interpreted as the trend of a country to experiment an episode of CO_2 emissions growth acceleration.

[10] Note also that it is assumed error terms, μ_i and υ_{it}, are distributed according to a normal law with a null mean and a variance, respectively σ_{μ}^{2} and 1. Under theses hypotheses, it is possible to estimate the β parameters by maximizing a conditional log likelihood function (Wooldridge, 2002).

Let Y_{it} $\begin{cases} = 1 \text{ if country } i \text{ experiments an episode of growth acceleration (when } Y_{it}^* > 0). \\ = 0 \text{ otherwise (when } Y_{it}^* \leq 0) \end{cases}$

. Results of the estimations for the three sub-samples, according to the source of data of primary energy consumption, are in appendix (appendix 8, tables 8.1 to 8.3) and are expressed in terms of average partial effects.

To begin with, I would like to underline that the integration of unobserved specific country-effects is supported by the rejection of the test on the parameter, ρ (cf. Appendix 8). The latter measures the relative importance of the unobserved effects since: $\rho = \frac{\sigma_\mu^2}{\sigma_\mu^2 + 1}$ with σ_μ^2 the variance of the random country-specific error term, μ_i in equation **(6)**.

On one hand, note that the results from the random-effects probit estimator are the same as those from the pooling regressions for the openness variables (columns (3a) and (3b), the growth rate of oil price (column 5) and the environmental consciousness variable (column 6c). Indeed, the binary index of Sachs and Warner is significant in samples 2 and 3 and had a positive effect (cf. tables 8.2 and 8.3). In this context, the idea that the openness of a nation leads to an increase in the probability of experiencing an acceleration growth episode is supported by empirical results. For the growth rate of oil price and the environmental consciousness, both variables are not significant, as in the pooling estimations. On the other hand, some differences appear. Firstly, one Kaya factor, the growth rate of energy intensity of growth, is significant on the longer sample only (cf. table 8.1) whereas it is significant in samples 1 and 3 in the pooling regressions. Moreover, the detailed demographic variables (columns (4a) and (4b)) are less significant when heterogeneity is taken into account. Indeed, the growth rate of urban population is significant in sample 3 only (cf. table 8.3); contrary to the pooling results where it was always significant. As for the structure of the population, the growth rate of the active population is now significant in samples 2 and 3 (cf. table 8.2 and 8.3). Finally, the ratification of the Kyoto protocol, and more precisely the membership to Annexe-I, seems to be a significant variable in previous estimations.

Once specific country-effects have been integrated, these variables are no longer significant (columns (6a) and (6b)).

To sum up, the integration of specific country effects reduces the significance of the growth rates of GDP per capita, of energy intensity of GDP, of urban population and of active population. However, it validates the significance of the openness of nations and the non-significance of the growth rate of oil price and the environmental consciousness.

3.3.2. CO_2 degrowth episodes

In this sub-section, let the underlying latent variable, Y_{it}^*, be interpreted as the trend of a country to experiment an episode of CO_2 emissions degrowth.

$$\text{Let } Y_{it} \begin{cases} = 1 \text{ if country } i \text{ experiments an episode of degrowth (when } Y_{it}^* > 0). \\ = 0 \text{ otherwise (when } Y_{it}^* \leq 0) \end{cases}$$

.

Results of the estimations for the three sub-samples, according to the source of data of primary energy consumption, are in appendix (appendix 9, tables 9.1 to 9.3) and are expressed in terms of average partial effects.

As for growth acceleration episodes, the integration of unobserved specific country-effects is supported by the rejection of the test on the parameter, ρ (cf. Appendix 9).

Concerning the Kaya factors, the pooling regressions provide strong evidence in favour of their significance, especially for three of them (the growth rates of GDP per capita, of population and of energy intensity of GDP). Empirical results from the random-effects probit change this conclusion. Indeed, whereas the growth rate of GDP per capita remains significant (except in sample 3) and has the negative expected effect; the growth rate of population and energy intensity of GDP are no longer significant. On the contrary, the growth rate of carbon intensity of energy appears now as a significant variable and has the expected negative effect. The replacement of the growth rate of GDP per inhabitant is inconclusive as a Wald test shows that explanatory variables are not jointly significant to explain the probability of a degrowth episode (column (2)). Concerning the openness variables, the binary index of Sachs and Warner is still significant (except in the longer sample, cf. table 9.1) and has the negative expected influence. A substantial modification of the conclusions appears when detailed demographic variables are integrated into the estimation. In the pooling regressions, those variables were significant in the three samples. Once specific country-effects have been implemented, note that the growth rate of urban population (column (4a)) is significant over the longer sample only (cf. table 9.1). As for the structure of the population, the growth rate of active population is significant over sample 3 only (cf. Table 9.3). The last four columns provides similar results as the growth rate of oil price, the ratification of the Kyoto Protocol and the increasing environmental awareness appear to be non-significant.

In a nutshell, the integration of specific country-effect reduces the significance of two Kaya factors, precisely the growth rates of population and of energy intensity of GDP, and of demographic variables, more precisely the growth rates of urban and active population. However, the probability of a CO_2 degrowth episode remains significantly and negatively linked to the growth rates of GDP per capita and of carbon intensity of energy and to the openness of nations.

3.4 Correcting for Endogeneity

In addition to the integration of heterogeneity between nations, the issue of endogeneity must be dealt with to improve the reliability of the estimations. Above all, the endogeneity problem can touch the growth rate of GDP per capita, so far supposed exogenous. It is possible that explanatory factors have not been considered in the regressions yet. It is even likely that such variables could also have an impact on the growth rate of GDP per capita. For example, the increasing awareness of climate warning can influence both pollutant emissions dynamics and economic growth. If the phenomenon of endogeneity is not taken into account, regressions are biased. Consequently, in this fourth sub-section, the econometric analysis is completed by the use of the two-stage approach of Rivers and Vuong (1988). This methodology enables to correct the endogeneity bias in the nonlinear model but also enables to test the endogeneity of the explanatory variable.

In this sub-section, the econometric model, represented by equation **(6)**, becomes the following (with Y_{it} equals 1 when $Y^{*}_{it} > 0$ and Y_{it} equals 0 otherwise):

$$Y^{*}_{it} = \beta_1' X_{it} + \gamma' W_{it} + \mu_i + \upsilon_{it}, \; i = 1, ..., N \; t = 1, ..., T \qquad \textbf{(7)}$$

where Y_{it}^{*} is the underlying latent variable, X_{it} is the set of exogenous explanatory variables specific to a country and/or to a year, β_1 is the vector of associated parameters, W_{it} is the endogenous explanatory variable (i.e the growth rate of GDP per capita), γ its associated parameter, μ_i is the random country effect and υ_{it} the residual term.

Due to omitted variables in the estimations, it is possible that the growth rate of GDP per capita is an endogenous variable, as $E(W_{it}, \upsilon_{it}) \neq 0$. To test the endogeneity of this variable, I use the method of Rivers and Vuong (1988) and extend it to a panel framework, as Elbadawi and Sambanis (2002). Firstly, a reduced model with random effects for the endogenous variable is estimated by generalized least squares:

$$W_{it} = \delta' X_{it} + \theta' Z_{it} + \varphi_i + \tau_{it} \qquad \textbf{(8)}$$

This model takes into account the set of explanatory variables from the non linear model, X_{it}, and also the set of instrumental variables[11], Z_{it}. The latter must satisfies two conditions: (1) the instrument(s) must be strongly correlated with the endogenous variable, W_{it} (2) and must be correlated neither with the binary variable, Y_{it}, nor the error term, υ_{it}. Once equation **(8)** has been estimated, predicted value for the endogenous variable, $\hat{W}_{it}$, and residuals, $\hat{\tau}_{it}$, are computed:

$$\hat{W}_{it} = \hat{\delta}' X_{it} + \hat{\theta}' Z_{it} \qquad \textbf{(9)}$$

[11] The choice of the instrumental variables for the growth rate of GDP per capita will be presented in the next sub-section after the description of the methodology.

$$\hat{\tau}_{it} = W_{it} - \hat{W}_{it} \quad (10)$$

The second stage of the methodology is to estimate the random-effects Probit model by adding the residuals, $\hat{\tau}_{it}$, as an explanatory variable:

$$Y^*_{it} = \beta'_1 X_{it} + \gamma' W_{it} + \beta'_2 \hat{\tau}_{it} + \mu_i + \upsilon_{it} \quad (11)$$

A nice feature of this methodology is that the usual probit t-statistics on β_2 is a valid test of the null hypothesis that W_{it} is exogenous, that is, Ho: $\beta_2 = 0$. If $\beta_2 \neq 0$, the usual probit standard errors and test-statistics, i.e estimations not corrected for the endogeneity phenomenon, are substantially biased. Note also that it is possible to consistently estimate the average partial effects after the two-stage estimation (see Wooldridge, 2002, p. 474-475 for a detailed description).

3.4.1 The choice of the instrumental variables

To find instruments for the growth rate of GDP per capita, I tried different variables coming from the literature on the determinants of economic growth. Therefore, following Barro and Sala-i-Martin (1995), I used the 10-years lagged log value of the level of GDP per capita (Maddison, 2008), the level of educational attainment (Barro and Lee, 2001), two indexes for political democratic rights and civil liberties (Marschall and Jaggers, 2007; Vanhanen, 2001) and the life expectancy at birth (United Nations, 2007). I also used the 10-years lagged value of the growth rate of GDP per capita. The choice of those factors is supported by the following arguments. For the lagged value of GDP per capita, the idea is based on the notion of conditional convergence; i.e the farther an economy locates away from its long-run (or steady-state) level, the higher is its economic growth. So, a negative relation between the growth rate of GDP per capita and its initial level is expected. Concerning the level of educational attainment, a positive link is supposed since growth theories emphasize human capital as a key factor to drive the long-term growth of income. To measure the human capital stock of a country, I use the average years of schooling of total population aged of 25 years and more estimated by Barro and Lee (2001). I also take into account the existence of democracy as economic performance can be influenced by altering the extent of democratic rights. In this context, two indexes have been separately used: the polity IV index of Marshall and Jaggers (2007) and the Vanhanen's measure (2001) (cf. appendix 10 for a description of these indices). The last but not the least instrumental variable implemented is the life expectancy at birth. Indeed, "it is likely that life expectancy at birth has such a strong, positive relation with growth because it proxies for features other than good health that reflect desirable performance for a society" (Barro and Sala-i-Martin, 1995).

I estimated equation **(8)** using those various instruments. Note that different versions of this estimation have been done. Indeed, I began by introducing the four instruments (lagged level or growth rate of GDP per capita, education attainment, democratic rights and life expectancy at birth). Unfortunately, the variables weren't all significant individually. As the instrumental variables must be strongly correlated with the endogenous variable, I dropped the lagged value of the growth rate of GDP per capita since it always was non-significant. So, I continued the estimations of the four possible combinations with three instrumental variables[12]. But, over the three sub-samples, the three variables were not always significant, except the lagged value of GDP per capita. Therefore, I estimated the three possible combinations with two instruments (the past value of income per capita and another variable)[13]. I found that the life expectancy at birth and the lagged log value of GDP per capita were individually significant over the three datasets. I kept those instruments to implement the two-stage Probit model on panel data.

However, note that instrumental variables are always subject to close scrutiny. Indeed, in linear models, a weak correlation between the instruments and the endogenous variable may make the two-stage estimation technique not to be superior to a simple regression where there is no attempt to control for the endogeneity bias (Bound *et al.*, 1995; Staiger and Stock, 1997; Stock *et al.*, 2002). In this context, the instruments must not be weak, i.e. they must be sufficiently correlated with the endogenous regressor. Following the criterion developed for the linear two-stage least squares model (Staiger

[12] The four combinations are the following: (i) lagged level of GDP per capita, education attainment, democratic rights, (ii) lagged level of GDP per capita, education attainment, life expectancy at birth, (iii) lagged level of GDP per capita, democratic rights, life expectancy at birth and (iv) education attainment, democratic rights, life expectancy at birth.

[13] The three combinations are the following: (i) lagged level of GDP per capita, education attainment (ii) lagged level of GDP per capita, life expectancy at birth, and (iii) lagged level of GDP per capita, democratic rights.

and Stock, 1997), I report the value of the F-statistic of a test of joint significance of instruments in the first stage regression. I also compute the partial R-squared from the including instruments in order to provide an idea of the additional explanatory power of instrumental variables.

3.4.2 CO_2 acceleration growth episode

Results of the estimations for the three sub-samples are in appendix (appendix 11, tables 11.1 to 11.3) and are expressed in terms of average partial effects.

In the first part of the tables, I report the most interesting results of the first-step estimation (cf. equation **(8)**), i.e the coefficients of the instrumental variables and their significance levels. It is clear that both instruments are always significant at the 1% level and have the expected sign: negative for the lagged log value of GDP per capita and positive for life expectancy at birth. Then, as instruments must not be weak, I provide data on the F-statistic of a test of their joint significance. Note that the null hypothesis is always rejected and that the F-statistic is always higher than 10. In this context, the chosen instrumental variables are not likely to be weak (Staiger and Stock, 1997). Moreover, including the instruments in the first-stage raises the R-squared, especially in samples 1 and 3. Therefore, instruments seem to have substantial explanatory power.

In the second part of the tables, I report results from the second-step estimation (cf. equation **(11)**). As I underline before, the methodology of Rivers and Vuong (1988) is interesting since it enables to test the hypothesis of exogeneity of an explanatory variable by looking at the significance of the residuals of the first stage. From table 11.1 (cf. appendix 11), since residuals are never significant, the growth rate of GDP per capita appears to be exogenous over the longer sample. Therefore, there is no need to correct for the endogeneity problem and empirical results from the Probit model with random effects are reliable (cf. appendix 8, table 8.1 and sub-section 3.3.1). The same result appears for sample 2 as residuals are not significant, except for the first regression with Kaya factors only (cf. appendix 11, table 11.2). In this context, over this dataset, conclusions can be based on the results of the Probit model with random effects (cf. appendix 8, table 8.2 and sub-section 3.3.1). However, for the last and shorter sample, residuals are significant for regressions (1) to (4a) and non significant otherwise (cf.

appendix 11, table 11.3). For the latter estimations (columns (4b) to (6c)), empirical results from the Probit model with random effects are reliable (cf. appendix 8, table 8.3). On the contrary, regressions (1) to (4a) must be corrected for the endogeneity problem and so results from the two-stage Probit model are reliable. Comparing them with uncorrected results, it appears that growth rates of Kaya factors are more significant but openness becomes non-significant.

To sum up, for the study of acceleration growth episodes, the hypothesis of exogeneity of the growth rate of GDP per capita is always accepted over samples 1 and 2. Therefore, uncorrected estimations from a Probit model with random effects are reliable. On the contrary, over the shorter sample, some regressions reject the exogeneity assumption. In this context, the two-step Probit model is used to correct for the endogeneity problem. To conclude, the probability of a CO_2 acceleration episode remains significantly and positively linked to the growth rates of GDP per capita, of energy intensity of GDP, of carbon intensity of energy, of active population and to the openness of nations. The growth rate of oil price and the environmental consciousness do not seem to influence the dynamic pattern of CO_2 emissions.

3.4.3 CO_2 degrowth episodes

Results of the estimations for the three sub-samples are in appendix (appendix 12, tables 12.1 to 12.3) and are expressed in terms of average partial effects.

Looking at the first part of the tables, both instruments are significant and have the expected sign: negative for the lagged log value of GDP per capita and positive for life expectancy at birth. Note however that the life expectancy at birth is significant at the 10 % only for some regressions. Nevertheless, data on the F-statistic of a test of joint significance of instruments show that the null hypothesis is always rejected. Moreover, including the instruments in the first-stage raises the R-squared, especially in samples 1 and 3. In this context, the chosen instrumental variables are not likely to be weak.

In the second part of the tables, results from the second-step estimation (cf. equation **(11)**) are reported. From table 12.1 (cf. appendix 12), since residuals are always significant, the growth rate of GDP per capita appears to be endogenous over the longer sample. Therefore, results must be corrected for the endogeneity problem thanks to the two-step Probit model. Comparing then with uncorrected results, the main change appears on the significance of the growth rates of Kaya factors. The four factors are now significant, once the endogeneity issue has been taken into account. The other modification is the significance of the environmental consciousness variable. Unfortunately, it has a surprising negative sign whereas it was expected to be positive. Concerning openness of nations, demographic variables, oil price and ratification of the Kyoto protocol, results are unchanged. As for samples 2 and 3 (cf. tables 12. 2 and 12.3), as residuals are not significant, empirical results from the Probit model with random effects are reliable (cf. appendix 9, tables 9.2 and 9.3, and sub-section 3.3.2).

To conclude on the analysis of degrowth episodes, over the longer temporal sample, the growth rate of GDP per capita is endogenous whereas it appears to be exogenous over the shorter samples. In this context, the probability of a degrowth episode is significantly and negatively linked to the growth rates of the Kaya factors in the long-term. Over shorter periods, the growth rates of GDP per capita and of carbon intensity of energy are still significant. Openness of nations is also significant and negative over shorter datasets.

3.5 Extension with a multinomial logit model

In this last sub-section, I present the empirical results of the multinomial logit model. I am now interesting in how ceteris paribus changes in the elements of the vector of the explanatory variables (*X*, with first-element unity) affect the response probabilities, P(Y= j| X), j=0,1,2. The theoretical econometric model is the following:

$$P(Y = j|X) = \frac{\exp(X\beta_j)}{1 + \sum_{h=1}^{2} \exp(X\beta_h)}, \; j = 1,2 \qquad \textbf{(12)}$$

Therefore, in the same estimation, I analyze simultaneously the probability of a CO_2 acceleration episode and the one of a degrowth episode[14].

[14] Note that specific-country effects are not integrated into the analysis and the GDP per capita growth rate is assumed to be exogenous.

So, let Y_{it} $\begin{cases} = 2 \text{ if country } i \text{ experiments an episode of degrowth,} \\ = 1 \text{ if country } i \text{ experiments an episode of acceleration growth,} \\ = 0 \text{ otherwise.} \end{cases}$

Note also that the explanatory variables are identical between the various situations but the associated parameters, β, are different according to the alternatives. Therefore, the effects of a partial change in a variable can have a different impact according to the situation analyzed.

Before presenting and interpreting empirical results, I underline that the multinomial logit model is based on the assumption of independence of irrelevant alternatives (IAA). This means that "the relative probabilities for any two alternatives depend only on the attributes of those two alternatives. […] (Therefore), adding another alternative or changing the characteristics of a third alternative does not affect the relative probabilities between alternatives *j* and *h*" (Wooldridge, 2002). The IAA property can impose very strong restrictions in the multinomial logit model. In order to obtain robust and relevant estimations, I test the IAA assumption in each regression[15]. I follow the methodology of Hausman and McFadden (1984). According to them, if the multinomial logit model is true, the β parameters can be consistently estimated by a multinomial logit focusing on any subset of alternatives. The Hausman principle comparing the estimate of β using all alternative to the one using a subset is applied. I use this test for each estimation and empirical results lead to the acceptance of the IAA hypothesis for all regressions as the statistic of the test was always lower than the theoretical value of a limited chi-squared distribution.

Results of the multinomial estimations for the three sub-samples, according to the source of data of primary energy consumption, are in appendix (appendix 13, tables 13.1 to 13.3) and are expressed in terms of average partial effects.

[15] The other possibility was to estimate a multinomial Probit model (MPM). As the test of the existence of the IAA assumption was accepted, I prefer to keep the estimation of the multinomial Logit model (MLM) as it is difficult to obtain the partial effects on the response probabilities in a MPM. Moreover, Dow and Endersby (2004) demonstrate that when used to study voter choice in multiparty candidate elections, MNL performs at least as well as MNP. For this reason, given the similarities in the levels of statistical significance in the two different methods here, I feel comfortable using the results of the MLM.

Concerning the Kaya factors (column (1)), it is striking that the growth rate of GDP per capita is significant and negative in the three samples for degrowth episodes but non significant and positive for accelerations episodes. The latter result is contrary to empirical results from the binomial probit model on the probability of an acceleration episode. Note also that the growth rate of energy intensity of GDP remains a significant variable for degrowth episodes but its level of significance is lower than in the binomial pooling model. As for the growth rate of carbon intensity of energy, significant variable for both types of episodes when heterogeneity and endogeneity are taken into account, it does not appear as a substantial explanatory variable in the multinomial model. The decomposition of the growth of GDP per capita with sectorial variables does not provide any relevant conclusions, as in previous models (column (2)). Next estimations clearly support previous results. Indeed, as with binary response models, the openness of nations is a significant variable with a positive effect on the probability of an acceleration growth episode but a negative one on the probability of a degrowth episode (columns (3a) and (3b)). Note this relation appears only with the index of openness developed by Sachs and Warner (1995). In this context, the openness of a country to global trade leads to a "polluting" size effect superior to the "less-polluting" composition and technique effects. Concerning demographic variables, results from the multinomial logit models underline the significant impact of the growth rates of urban and active population (columns (4a) and (4b)) over the three samples. These variables have a negative effect on the probability of a degrowth episode and a positive one on the probability of an acceleration episode. Therefore, this analysis corroborates the studies of York *et al.* (2003) and Cole and Neumayer (2004) on the importance of demographic variables on pollutant emissions patterns. Note however that significance levels of these variables are lower in the binary model, with country random effects, corrected for endogeneity. Column (5) presents the results of the estimation with the oil price growth rate. For degrowth episodes, it is significant (at 10 %) on the longer sample only, as in binary models (cf. table 13.3). As for acceleration growth events, this variable is significant in the first and second samples at 10 % only and had the expected negative effect whereas it was non-significant in the binomial models. The three last estimations deals with the environmental consciousness of nations. Over the three samples[16], the ratification of the Kyoto protocol, and more precisely the membership to Annex-I, is a

[16] Remind that, in the third sample, the reference situation is the members of the non-Annex-I.

significant variable for acceleration episodes (column (6a) and (6b)), contrary to results from the corrected binomial models with country effects. Unfortunately, it has an unexpected positive effect. Results from the multinomial logit model support the idea that countries of the Annex-I have not yet implement policies leading to a reduction of CO_2 emissions and so an achievement of Kyoto targets. Concerning the variable describing the global environmental consciousness, it is always significant for acceleration growth episodes (column (6c)). But it has a surprising positive effect over the longer periods (cf. table 13.1 and 13.2) and an expected negative effect over on the shorter sample (cf. table 13.3). According to these conflicting results, the relevance of this variable is in question. An interesting extension of the study would be to develop national measures of environmental consciousness and integrate them into the econometric analysis.

To sum up, the multinomial logit model supports the conclusions of the binomial models. All the Kaya factors are not significant and influence more the probability of degrowth episodes. Other important explanatory variables seem to be the openness of nations and the growth rates of urban and active population. The estimations do not provide any evidence in favour of a positive effect of national environmental consciousness, despite the increasing awareness of the issue of environmental protection and climate change.

4. Conclusion

The goal of this paper was to analyze precisely the dynamics of CO_2 emissions in term of growth rate. In the first part of the article, basing on Hausman *et al.* (2005), a filter to identify episodes of CO_2 emissions growth acceleration is developed. In a context of fight against global warming, episodes of CO_2 emissions degrowth are also identified. Both filters are composed of three conditions on the level of growth rate, its change and post-episode emissions. I apply these filters on a dataset composed of 124 countries over the period 1950-2004: 285 episodes of growth acceleration are identified and 78 degrowth episodes. After having identified episodes of growth accelerations and degrowth, I examine the determinants of those episodes in an econometric analysis described in the second part of the paper. This step of the study is essential since it can give some ideas on the drivers of CO_2 emissions accelerations and also on the factors explaining degrowth episodes. After estimating pooling regressions, I introduce specific-country random effects to control for unobserved heterogeneity between nations. In order to obtain unbiased and relevant econometric results, I also correct for the endogeneity problem by implementing the two-step Probit estimator on panel data. Finally, I extend the econometric analysis by estimating a multinomial logit model and I compare its results to the ones of binomial estimations. To sum up, empirical results show that the Kaya factors are not all significant and influence more the probability of degrowth episodes. Indeed, the growth rates of GDP per capita, of population and of carbon intensity of energy has a significant negative effect on the probability of a degrowth episode. For both types of episodes, the openness of nations and the growth rates of urban and active population are also significant explanatory variables, having a positive (negative) effect on the probability of an acceleration growth (degrowth) episode. Finally, the expected positive effect of national environmental consciousness is not corroborated by these estimations.

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Appendix

Appendix 1. List of countries in the sample (N=124, T=1950-2004)

Regions	**List of countries**
Asia (N=14)	Brunei, China, Dem. of Korea, Hong-Kong, Japan, India, Indonesia, Mongolia, Myanmar, Philippines, Rep. of Korea, Sri Lanka, Taiwan, Thailand.
Africa (N=27)	Algeria, Angola, Cameroon, Capa Verde, Djibouti, Egypt, Equatorial Guinea, French Guinea, Gambia, Ghana, Gibraltar, Kenya, Liberia, Libyan Arabia, Madagascar, Mauritius, Morocco, Mozambique, Nigeria, Reunion, Sierra Leone, South Africa, Sudan, Togo, Tunisia, Uganda, Zaire.
Middle (N=10)	Bahrain, Iraq, Iran, Israel, Jordan, Kuwait, Lebanon, Qatar, Saudi Arabia, Syrian Arab Republic.
Europe (N=26)	Albania, Austria, Belgium, Bulgaria, Cyprus, Czechoslovakia, Denmark, Faroe Islands, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, U.K.
Latin America (N=31)	Argentina, Bolivia, Brazil, Barbados, Belize, Chile, Colombia, Costa Rica, Cuba, Dominican Rep., Ecuador, El Salvador, Grenada, Guadeloupe, Guatemala, Guyana, Honduras, Haiti, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela.
North America (N=2)	Canada, U.S.A.
Other (N=14)	Australia, Bahamas, Bermuda, Fiji, Greenland, Iceland, New-Caledonia, New-Zealand, Papua New Guinea, Samoa, Saint Pierre and Miquelon, Tonga, Turkey, U.S.S.R.

Appendix 2: Empirical Results of the variations of the filters

❶ Growth Accelerations

$g_{t,t+n}$	**2.75 %**						**3.5 %**					
n	**8 years**			**5 years**			**8 years**			**5 years**		
Δg	***1%***	***2%***	***3%***	***1%***	***2%***	***3%***	***1%***	***2%***	***3%***	***1%***	***2%***	***3%***
Number of episodes	346	285	237	535	490	437	327	277	229	521	478	433
Probability	9.35%	7.23%	5.73%	14.51%	12.67%	10.71%	8.07%	6.97%	5.49%	13.91%	12.24%	10.57%
Average growth rate acceleration	9.46%	10.14%	10.87%	10.83%	11.35%	12.14%	9.84%	10.50%	11.10%	11.11%	11.51%	12.21%
Median growth rate acceleration	7.81%	8.68%	9.17%	8.83%	9.36%	10.04%	8.30%	8.88%	9.39%	9.06%	9.57%	10.04%
Number of countries with 1 episode or more	120 96.77%	114 91.93%	109 87.90%	123 99.19%	123 99.19%	120 96.77%	117 94.35%	114 91.93%	109 87.90%	123 99.19%	123 99.19%	120 96.77%
Number of countries with 3 episodes or more	76 61.29%	61 49.19%	42 33.87%	114 91.93%	106 85.48%	98 79.03%	74 59.67%	60 48.39%	37 29.84%	108 87.10%	102 82.26%	104 83.87%
Conditional Average of episode per country	2.91	2.51	2.18	4.35	3.98	3.64	2.79	2.43	2.1	4.23	3.89	3.61
Conditional Median of episode per country	3	3	2	4	4	4	3	3	2	4	4	4

Note: The grey column corresponds to the benchmark definition of a growth acceleration.

❷ Degrowth episodes

$g_{t,t+n}$	**- 1 %**						**- 2 %**					
n	**8 years**			**5 years**			**8 years**			**5 years**		
Δg	*0%*	*-1%*	*-2%*	*0%*	*-1%*	*-2%*	*0%*	*-1%*	*-2%*	*0%*	*-1%*	*-2%*
Number of episodes	88	83	78	116	113	107	75	74	69	107	106	103
Probability	1.86 %	1.75 %	1.63 %	2.16%	2.1%	1.98%	1.57%	1.54%	1.43%	1.98%	1.96%	1.90%
Average degrowth rate	-6.3%	-6.4%	-6.7%	-8.8%	-9%	-9.2%	-7%	-7.13%	-7.51%	-9.5%	-9.56%	-9.76%
Median degrowth rate	-4.9%	-5.1%	-5.4%	-6.7%	-6.7%	-7%	-5.7%	-5.7%	-5.9%	-7%	-7.14%	-7.33%
Number of countries with 1 episode or more	60 48.39%	60 48.39%	59 47.58%	76 61.29%	76 61.29%	75 60.48%	54 43.55%	54 43.55%	53 42.74%	74 59.68%	74 59.68%	73 58.87%
Number of countries with 2 episodes or more	20 16.13%	18 14.52%	16 12.90%	27 21.77%	27 21.77%	22 17.74%	17 13.71%	16 12.90%	14 11.29%	24 19.35%	24 19.35%	22 17.74%
Conditional Average of episode per country	1.47	1.38	1.32	1.53	1.49	1.41	1.39	1.37	1.3	1.44	1.43	1.41
Conditional Median of episode per country	1	1	1	1	1	1	1	1	1	1	1	1

Note: The grey column corresponds to the benchmark definition of a degrowth episode.

Appendix 3: List of countries in the three sub-samples

Name of the sample	Source of data for energy consumption	Temporal Dataset	Number of countries
Sample 1	British Petroleum	1965-1997	48
List of countries: Algeria, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Czechoslovakia, Denmark, Ecuador, Egypt, Finland, France, Germany, Greece, Hungary, India, Indonesia, Iran, Ireland, Italy, Japan, Korea, Kuwait, Mexico, Netherlands, Norway, New Zealand, Peru, Philippines, Poland, Portugal, Romania, Spain, South Africa, Sweden, Switzerland, Taiwan, Thailand, Turkey, U.K, U.SA., U.R.S.S, Venezuela.			
Sample 2	World Bank	1971-1997	76
List of countries: Algeria, Argentina, Australia, Austria, Bahrain, Belgium, Bolivia, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Cuba, Cyprus, Czechoslovakia, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Germany, Ghana, Greece, Guatemala, Haiti, Honduras, Hungary, India, Israel, Indonesia, Iraq, Iran, Ireland, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Mexico, Mozambique, Myanmar, Netherlands, Nicaragua, Norway, New Zealand, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Spain, South Africa, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, U.K, Uruguay, U.SA., Venezuela, Zaire.			
Sample 3	Energy Information Administration	1980-1991	83
List of countries: Algeria, Argentina, Australia, Austria, Bahrain, Belgium, Bolivia, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Cuba, Cyprus, Czechoslovakia, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Gambia, Germany, Ghana, Greece, Guatemala, Haiti, Honduras, Hungary, India, Israel, Indonesia, Iraq, Iran, Ireland, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Liberia, Mauritius, Mexico, Mozambique, Myanmar, Netherlands, Nicaragua, Norway, New Zealand, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Sierra Leone, Spain, South Africa, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Taiwan, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, Uganda, U.K, Uruguay, U.SA., U.R.S.S., Venezuela, Zaire.			

Appendix 4: Explanatory Variables: Sources and Expected Effects

Explanatory Variables	Name in Estimation Tables	Source	Expected effects on Acceleration episodes	Expected effects on Degrowth episodes
GDP per capita growth rate	*gGDP*	Maddison	+	-
Population growth rate	*gPOP*		+	-
Energy intensity growth rate	*gENER-INT*	1- British Petroleum 2- Energy Information Administration 3- World Bank	+	-
Carbon intensity growth rate	*gCARB-INT*	Marland	+	-
Growth rate of per capita value added in agriculture	*gVA-AGR*	World Bank	+	-
Growth rate of per capita value added in industry	*gVA-IND*		+	-
Growth rate of per capita value added in services	*gVA-SERV*		-	+
Openness Ratio	*Openness 1*	World Trade Organization	+	-
Sachs and Warner Index	*Openness 2*	Sachs & Warner Wacziarg & Welch	+	-
Urban population growth rate	*gURB-POP*	World Bank	+	-
Growth rate of young population	*gPOP-y*		-	+
Growth rate of active population	*gPOP-a*		+	-
Growth rate of retired population	*gPOP-r*		-	+
Growth rate of oil price	*gOIL*	British Petroleum	-	0
Ratification of the Kyoto Protocol	*Protocol*	UNFCC	-	+
Member of the Annex I of the Kyoto Protocol	*Protocol1*		-	+
Member of the non-Annex I of the Kyoto Protocol	*Protocol2*		-	+
Environmental consciousness	*Consciousness*	From the author	-	0

Appendix 5: Predicting growth accelerations episodes for the three sub-samples

Table 5.1	**Sample 1 - 1966-1997**									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
gGDP	0.334 (1.36)		0.299 (1.14)	0.156 (0.65)	0.161 (0.70)	0.480** (1.92)	0.486** (1.95)	0.478 ** (1.93)	0.209 (0.99)	0.531 ** (2.08)
gPOP	0.298 (0.28)	0.291 (0.03)	0.264 (0.25)	7.484*** (6.58)						
gENER-INT	0.60*** (2.59)	0.744*** (2.94)	0.571 ** (2.43)	0.375 * (1.63)	0.412 * (1.73)	0.588*** (2.51)	0.585*** (2.49)	0.579 *** (2.51)	0.439 ** (2.01)	0.619 *** (2.62)
gCARB-INT	0.389** (2.23)	0.384** (2.02)	0.374 ** (2.12)	0.365 ** (2.05)	0.375 ** (2.18)	0.405** (2.38)	0.407** (2.40)	0.399 ** (2.39)	0.399 *** (2.67)	0.402 ** (2.39)
gVA-AGR		-0.018 (-0.17)								
gVA-IND		0.335** (2.10)								
gVA-SERV		0.171 (0.83)								
Openness 1			-0.263 (-1.46)							
Openness 2				0.029 (1.30)						
gURB-POP					0.037 *** (6.79)					
gPOP-y						-0.876 (-1.18)	-0.821 (-1.12)	-0.865 (-1.18)	-0.949 (-1.30)	-0.785 (-1.06)
gPOP-a						3.594 *** (3.06)	3.54 *** (3.03)	3.619 *** (3.11)	1.454 (1.35)	3.635 *** (3.03)
gPOP-r						-2.343 *** (-2.61)	-2.317 *** (-2.59)	-2.360 *** (-2.65)	-1.035 (-1.33)	-2.416 *** (-2.64)
gOIL							-0.031 (-1.27)			
Protocol								0.0863 ** (1.88)		
Protocol1									0.210 *** (3.11)	
Protocol2									0.029 (0.52)	
Consciousness										0.005 (1.26)
Observations/Groups	1200/48	976/47	1174/47	1181/47	1174/47	1174/47	1174/47	1174/47	1174/47	1174/47
Number of episodes	55	50	55	53	52	52	52	52	52	52
Log-likelihod	-475.004	-407.79	-463.62	-429.97	-443.18	-457.93	-456.83	-45597	-431.28	-457.18
Pseudo-R²	1.51	2.22	1.97	7.11	6.30	3.18	3.41	3.59	8.81	3.33

Note: Estimated by Probit. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistics. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10% (*).

Table 5.2 **Sample 2 - 1972-1997**

	(1)	(2)	(3a)	(3b)	(4a)	(4b)	(5)	(6a)	(6b)	(6c)
gGDP	0.561 **		0.575 **	0.503 **	0.319	0.489 **	0.529 **	0.486 **	0.407 *	0.552 **
	(2.36)		(2.37)	(2.10)	(1.35)	(2.07)	(2.23)	2.06)	(1.81)	(2.33)
gPOP	1.730	1.265	1.736	8.710 ***						
	(1.14)	(0.84)	(1.14)	(9.13)						
gENER-INT	0.281 *	0.210	0.292 *	0.186	0.129	0.208	0.212	0.224	0.168	0.223
	(1.60)	(0.91)	(1.62)	(0.94)	(0.74)	(1.07)	(1.07)	(1.14)	(0.89)	(1.17)
gCARB-INT	0.101	0.101	0.101	0.054	0.053	0.051	0.0509	0.048	0.043	0.043
	(1.40)	(1.30)	(1.38)	(0.80)	(0.79)	(0.80)	(0.80)	(0.76)	(0.70)	(0.68)
gVA-AGR		0.004								
		(0.04)								
gVA-IND		0.303 ***								
		(2.56)								
gVA-SERV		0.089								
		(0.52)								
Openness 1			-0.029							
			(-0.84)							
Openness 2				0.059 ***	0.043 **	0.066 ***	0.063 ***	0.067 ***	0.094 ***	0.051 **
				(2.60)	(1.97)	(2.83)	(2.72)	(2.87)	(3.83)	(2.10)
gURB-POP					0.049 ***					
					(8.41)					
gPOP-y						1.362 *	1.417 *	1.393 *	1.11	1.381 *
						(1.80)	(1.89)	(1.85)	(1.48)	(1.84)
gPOP-a						7.459 ***	7.40 ***	7.497 ***	5.27 ***	7.545 ***
						(6.96)	(6.87)	(7.03)	(4.81)	(6.90)
gPOP-r						-0.619	-0.633	-0.632	-1.037	-0.793
						(-0.74)	(-0.76)	(-0.76)	(-1.21)	(-0.94)
gOIL							-0.031			
							(-1.53)			
Protocol								0.071 *		
								(1.67)		
Protocol1									0.106 **	
									(2.13)	
Protocol2									-0.015	
									(-0.29)	
Consciousness										0.011 ***
										(2.64)
Observations/Groups	1480/76	1257/71	1477/76	1429/73	1429/73	1429/73	1429/73	1429/73	1429/73	1429/73
Number of episodes	91	82	91	86	86	86	86	86	86	86
Log-likelihod	-696.03	-608.52	-695.16	-620.15	-631.67	-613.62	-612.12	-612.27	-604.72	-610.60
Pseudo-R^2	1.63	1.63	1.67	7.68	5.97	8.66	8.87	8.86	9.98	9.11

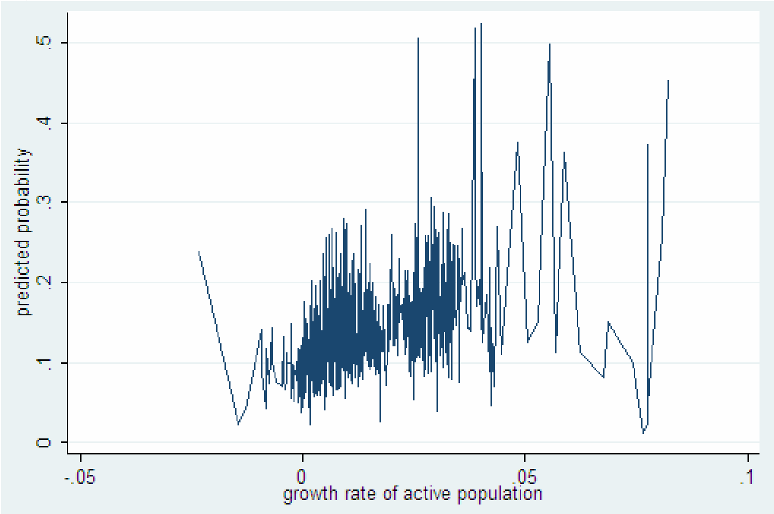
See the notes to Table 5.1.

Table 5.3	Sample 3 - 1981-1997									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
gGDP	1.058 ** (3.22)		1.053 *** (3.16)	1.005 *** (2.99)	0.832 *** (2.72)	0.754 ** (2.34)	0.753 ** (2.34)	0.741 ** (2.28)	0.654 ** (2.08)	0.77 ** (2.35)
gPOP	1.682 (1.15)	0.921 (0.72)	1.689 (1.16)	9.213 *** (8.52)						
gENER-INT	0.359 *** (2.55)	0.259 ** (1.67)	0.351 ** (2.49)	0.313 ** (2.56)	0.304 ** (2.28)	0.313 ** (2.28)	0.314 ** (2.29)	0.320 ** (2.34)	0.276 ** (2.07)	0.320 ** (2.32)
gCARB-INT	0.074 (0.97)	0.041 (0.53)	0.068 (0.89)	0.055 (0.77)	0.036 (0.51)	0.056 (0.84)	0.055 (0.82)	0.052 (0.78)	0.047 (0.72)	0.061 (0.90)
gVA-AGR		0.101 (0.83)								
gVA-IND		0.059 (0.62)								
gVA-SERV		0.088 (0.55)								
Openness 1			0.00 *** (-7.95)							
Openness 2				0.098 *** (3.56)	0.090 *** (3.28)	0.101 *** (3.63)	0.101 *** (3.63)	0.103 *** (3.73)	0.123 *** (4.33)	0.109 *** (3.76)
gURB-POP					0.054 *** (8.21)					
gPOP-y						-2.173 ** (-2.43)	-2.179 ** (-2.43)	-2.115 ** (-2.38)	-2.36 *** (-2.64)	-2.136 ** (-2.37)
gPOP-a						11.576 *** (7.86)	11.586 ** (7.83)	11.68 *** (7.98)	9.897 *** (6.42)	11.403 *** (7.69)
gPOP-r						0.991 (1.00)	0.985 (0.99)	0.943 (0.96)	0.357 (0.34)	1.176 (1.14)
gOIL							0.007 (0.12)			
Protocol								0.125 *** (2.22)		
Protocol1									0.174 ** (2.42)	
Protocol2									0.073 (0.97)	
Consciousness										-0.069 (-1.20)
Observations/Groups	1055/83	930/77	1044/82	1008/79	997/78	997/78	997/78	997/78	997/	997/78
Number of episodes	76	69	75	71	70	70	70	70	70	70
Log-likelihod	-535.44	-486.96	-528.88	-417.17	-474.91	-441.47	-441.47	-438.57	-435.07	-440.71
Pseudo--R²	2.30	0.01	2.23	9.13	7.23	13.76	13.76	14.33	15.01	13.91

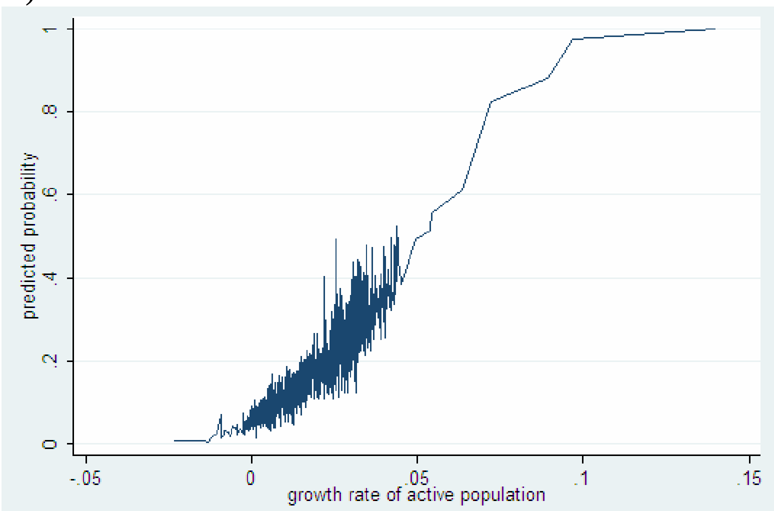
See the notes to Table 5.1.

Appendix 6: Predicted Probability and the growth rate of active population

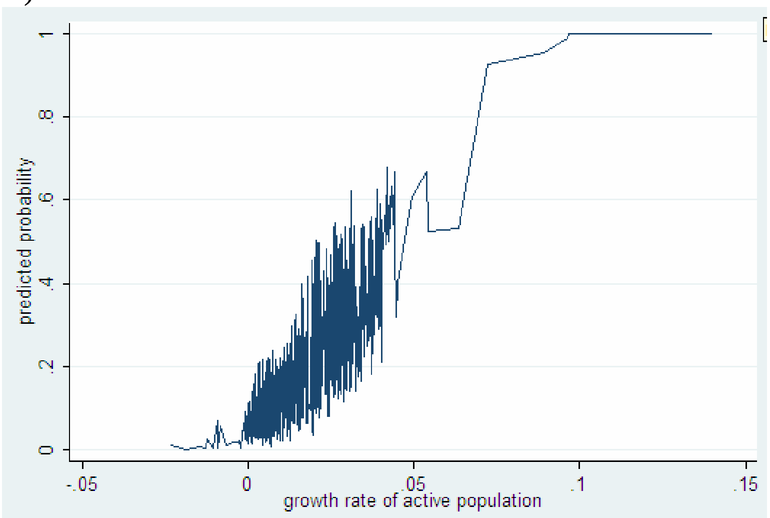
Sample 1 (column 4b)



Sample 2 (column 4b)



Sample 3 (column 4b)



Appendix 7: Predicting degrowth episodes for the three sub-samples

Table 7.1	**Sample 1 - 1966-1997**									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
gGDP	-0.788*** (-5.74)		-0.773*** (-5.42)	-0.613*** (-4.66)	-0.469*** (-3.23)	-0.566*** (-4.01)	-0.613*** (-4.66)	-0.616*** (-4.65)	-0.618*** (-4.62)	-0.627*** (-4.65)
gPOP	-0.945 (-1.27)	-0.884 (-1.08)	-0.903 (-1.20)	-4.304*** (-4.87)			-4.25*** (-4.86)	-4.34*** (-4.75)	-3.873*** (-3.45)	-4.31*** (-4.89)
gENER-INT	-0.45*** (-3.25)	-0.405** (-2.54)	-0.449*** (-3.17)	-0.345** (-2.44)	-0.295** (-2.03)	-0.337** (-2.35)	-0.359** (-2.50)	-0.345** (-2.43)	-0.346** (-2.44)	0.348** (-2.43)
gCARB-INT	-0.132 (-1.38)	-0.117 (-1.12)	-0.133 (-1.37)	-0.152 (-1.50)	-0.136 (-1.27)	-0.162 (-1.58)	-0.155 (-1.54)	-0.153 (-1.50)	-0.155 (-1.51)	-0.154 (-1.50)
gVA-AGR		0.055 (0.75)								
gVA-IND		-0.382*** (-4.33)								
gVA-SERV		-0.178 (-1.21)								
Openness 1			0.003 (1.09)							
Openness 2				-0.039*** (-2.85)	-0.054*** (-3.68)	-0.035** (-2.59)	-0.04** (-2.88)	-0.04** (-2.89)	-0.041*** (-2.86)	-0.037*** (-2.64)
gURB-POP					-0.037*** (-5..81)					
gPOP-y						-0.562 (-1.42)				
gPOP-a						-2.359*** (-3.74)				
gPOP-r						-1.183*** (-2.74)				
gOIL							-0.017 (-1.53)			
Protocol								-0.008 (-0.29)		
Protocol1									-0.014 (-0.55)	
Protocol2									-0.0027 (-0.09)	
Consciousness										-0.0015 (-0.6)
Observations/Groups	1398/48	1127/47	1366/47	1378/47	1346/46	1346/46	1378/47	1378/47	1378/47	1378/47
Number of episodes	27	23	26	25	25	25	25	25	25	25
Log-likelihod	-294.08	-243.71	-292.36	-260.94	-252.76	-258.68	-260.07	-260.89	-260.76	-270.77
Pseudo-R²	4.93	5.11	4.89	10.40	12.67	10.62	10.70	10.42	10.46	10.46

Note: Estimated by Probit. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistics. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10% (*).

Table 7.2	Sample 2 - 1972-1997									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
gGDP	-0.723*** (-5.30)		-0.756*** (-5.42)	-0.622*** (-4.65)	-0.553*** (-3.90)	-0.613*** (-4.57)	-0.618*** (-4.63)	-0.623*** (-4.64)	-0.6192*** (-4.51)	-0.6521*** (-4.85)
gPOP	-1.799*** (-3.63)	-1.453** (-2.50)	-1.796*** (-5.71)	-2.928*** (-4.97)			-2.699*** (-5.25)	-2.907** (-4.93)	-1.848*** (-3.27)	-2.828*** (-4.81)
gENER-INT	-0.342*** (-3.46)	-0.082 (-0.58)	-0.360*** (-3.61)	-0.325*** (-3.30)	-0.268*** (-2.56)	-0.332*** (-3.39)	-0.332** (-3.36)	-0.318*** (-3.18)	-0.299*** (-2.95)	-0.325*** (-3.32)
gCARB-INT	-0.0722 (-1.15)	-0.082 (1.10)	-0.074 (-1.19)	-0.1026 (-1.60)	-0.092 (-1.57)	-0.098 (-1.53)	-0.107 (-1.67)	-0.102 (-1.60)	-0.0801 (-1.25)	-0.099 (-1.49)
gVA-AGR		0.0032 (-0.05)								
gVA-IND		-0.155** (-2.34)								
gVA-SERV		-0.174 (-1.35)								
Openness 1			0.019 (1.06)							
Openness 2				-0.055** (-4.28)	-0.0447*** (-3.62)	-0.0543*** (-4.01)	-0.0571*** (-4.52)	-0.0546*** (-4.29)	-0.0744*** (-5.48)	-0.0422*** (-3.15)
gURB-POP					-0.011** (-2.48)					
gPOP-y						0.294 (-0.67)				
gPOP-a						-2.134*** (-3.82)				
gPOP-r						-0.671* (-1.65)				
gOIL							-0.015 (-1.48)			
Protocol								-0.015 (-0.46)		
Protocol1									-0.002 (-0.06)	
Protocol2									0.059 (1.33)	
Consciousness										-0.007** (-2.55)
Observations/Groups	1767/76	1503/71	1764/76	1705/73	1705/73	1705/73	1705/73	1705/73	1705/73	1705/73
Number of episodes	40	30	40	38	38	38	38	38	38	38
Log-likelihod	-419.17	-331.44	-417.98	-387.50	-398.76	-383.72	-386.51	-387.38	-381.91	-384.22
Pseudo-R²	4.43	2.70	4.65	7.40	4.71	8.31	7.64	7.43	8.74	8.19

See the notes to Table 7.1.

Table 7.3	**Sample 3 - 1981- 1997**								
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6')**	**(6'')**
gGDP	-0.665***		-0.654***	-0.385***	-0.357**	-0.317**	-0.386***	-0.491***	-0.392***
	(-4.17)		(-4.04)	(-2.58)	(-2.34)	(-2.19)	(-2.59)	(-3.02)	(-2.63)
gPOP	-1.979***	-1.049**	-1.967***	-3.687***			-3.693***	-1.964***	-3.679
	(-3.44)	(-1.95)	(-3.40)	(-5.86)			(-5.88)	(-2.82)	(-5.84)
gENER-INT	-0.262**	-0.202*	-0.257**	-0.23**	-0.169	-0.235**	-0.231**	-0.112	-0.228**
	(-2.13)	(-1.70)	(-2.08)	(-2.01)	(-1.44)	(-2.31)	(-2.03)	(-1.00)	(-1.99)
gCARB-INT	-0.173**	-0.129*	-0.172**	-0.197**	-0.146**	-0.198***	-0.199**	-0.129	-0.195**
	(-2.33)	(-1.80)	(-2.27)	(-2.51)	(-2.03)	(-2.68)	(-2.53)	(-1.45)	(-2.47)
gVA-AGR		-0.814							
		(1.09)							
gVA-IND		-0.182**							
		(-2.21)							
gVA-SERV		-0.262**							
		(-2.11)							
Openness 1			0.003						
			(1.02)						
Openness 2				-0.104***	-0.104***	-0.094***	-0.104***	-0.133***	-0.096***
				(-6.37)	(-6.50)	(-5.45)	(-6.46)	(-5.98)	(-6.39)
gURB-POP					-0.025***				
					(-3.85)				
gPOP-y						0.998*			
						(1.81)			
gPOP-a						-4.105***			
						(-5.01)			
gPOP-r						-0.639			
						(-1.54)			
gOIL							0.0153		
							(0.47)		
Protocol1								-0.094***	
								(-3.79)	
Consciousness									-0.003
									(-1.18)
Observations/Groups	1218/83	1081/77	1201/82	1168/79	1151/78	1151/78	1168/79	1103/75	1168/79
Number of Episodes	26	19	26	23	23	23	23	23	23
Log-likelihod	-266.16	-203.78	-264.83	-219.34	-221.15	-206.58	-219.23	-207.09	-218.82
Pseudo-R²	6.42	6.26	6.42	15.42	14.39	20.03	15.47	18.89	15.63

See the notes to Table 7.1.

Appendix 8: Predicting accelerations growth episodes while taking into account heterogeneity

Table 8.1	**Sample 1 - 1966-1997**									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
GDP per capita growth	0.157		0.154	0.115	0.240	0.181	0.161	0.159	0.168	0.181
	(0.94)		(0.79)	(0.44)	(1.37)	(0.86)	(0.80)	(0.83)	(0.96)	(0.97)
Population Growth	-0.917	-0.663	-0.892	1.448			-0.827	-0.901	-2.996	-0.785
	(-0.44)	(-0.31)	(-0.42)	(0.48)			(-0.35)	(-0.35)	(-1.32)	(-0.31)
Energy intensity growth	0.443 ***	0.344 **	0.405 **	0.312 **	0.361 **	0.426 **	0.450 ***	0.443 ***	0.425 ***	0.459 ***
	(3.14)	(2.45)	(2.04)	(2.04)	(2.12)	(2.08)	(2.74)	(2.87)	(2.53)	(2.66)
Carbon intensity growth	0.339 ***	0.244 ***	0.314 ***	0.277 **	0.277 ***	0.317 **	0.336 ***	0.338 ***	0.338 ***	0.338 ***
	(3.59)	(3.36)	(3.00)	(2.43)	(2.77)	(2.39)	(3.79)	(3.45)	(3.37)	(2.86)
Agriculture VA growth		-0.013								
		(-0.27)								
Industry VA growth		0.094								
		(1.25)								
Services VA growth		0.069								
		(0.59)								
Openness 1			0.114							
			(-0.95)							
Openness 2				0.021						
				(0.41)						
Urban population growth					-0.004					
					(-0.25)					
Young population growth						-1.085				
						(-0.61)				
Active population growth						-0.193				
						(-0.12)				
Old population growth						0.702				
						(-0.34)				
Oil price growth							-0.032			
							(-1.31)			
Kyoto Protocol								0.038		
								(0.16)		
Protocol-1									0.202	
									(0.52)	
Protocol-2									-0.066	
									(-0.21)	
Environmental consciousness										0.003
										(0.58)
Observations/Groups	1200/48/55	976/47/47	1174/47/47	1181/47/47	1174/47/47	1174/47/47	1200/48/55	1200/48/55	1200/48/55	1200/48/55
Log-likelihod	-389.03	-344.42	-377.71	-376.77	-381.12	-377.70	-387.21	-388.93	-380.36	-388.58
Pseudo-R^2	1.81	1.78	2.05	1.11	1.17	2.05	2.27	1.83	3.99	1.92
Wald Test (Prob H_o accepted)	12.44 (0.014)	16.30 (0.012)	14.88 (0.011)	10.56 (0.061)	16.25 (0.002)	16.95 (0.009)	18.82 (0.002)	11.88 (0.036)	43.69 (0.00)	17.29 (0.004)
Rho (Prob Rho = 0 accepted)	0.565 (0.00)	0.545 (0.00)	0.575 (0.00)	0.507 (0.00)	0.561 (0.00)	0.587 (0.00)	0.566 (0.00)	0.562 (0.00)	0.496 (0.00)	0.563 (0.00)

Note: Estimated by Probit with specific country random effects. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistic. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10 % (*).

Table 8.2	Sample 2 - 1972-1997									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
GDP per capita growth	0.481 **		0.485 **	0.395	0.296	0.431 *	0.475 **	0.431 **	0.353 *	0.485
	(2.11)		(1.92)	(1.26)	(1.31)	(1.86)	(1.91)	(1.89)	(1.63)	(1.50)
Population Growth	0.206	-0.003	0.247	4.54 **						
	(0.11)	(-0.001)	(0.15)	(2.11)						
Energy intensity growth	0.118	0.024	0.119	0.162	0.077	0.193	0.199	0.197	0.116	0.218
	(0.75)	(0.17)	(0.90)	(0.92)	(0.60)	(1.36)	(1.13)	(1.23)	(0.73)	(1.33)
Carbon intensity growth	0.085	0.072	0.083	0.049	0.056	0.046	0.044	0.045	0.041	0.038
	(0.99)	(0.70)	(0.90)	(0.54)	(0.67)	(0.51)	(0.65)	(0.74)	(0.44)	(0.58)
Agriculture VA growth		-0.024								
		(-0.32)								
Industry VA growth		0.200 ***								
		(3.04)								
Services VA growth		0.066								
		(0.49)								
Openness 1			-0.052							
			(-0.58)							
Openness 2				0.092 **	0.094 **	0.089 **	0.085 *	0.089 *	0.114 ***	0.060
				(2.28)	(2.50)	(2.18)	(1.83)	(1.67)	(3.19)	(1.40)
Urban population growth					0.026					
					(1.49)					
Young population growth						0.489	0.620	0.509	0.035	0.741
						(0.28)	(0.35)	(0.30)	(0.02)	(0.50)
Active population growth						4.681 *	4.696 **	4.730 **	2.629	4.881 *
						(1.89)	(1.91)	(2.02)	(1.37)	(1.77)
Old population growth						-0.432	-0.497	-0.432	-0.804	-0.707
						(-0.30)	(-0.26)	(-0.24)	(-0.45)	(-0.35)
Oil price growth							-0.030			
							(-1.56)			
Kyoto Protocol								0.052		
								(0.58)		
Protocol-1									0.111	
									(0.33)	
Protocol-2									-0.114	
									(-0.36)	
Environmental consciousness										0.010 *
										(1.66)
Observations/Groups	1480/76/91	1257/71/82	1477/76/91	1429/73/86	1429/73/86	1429/73/86	1429/73/86	1429/73/86	1429/73/86	1429/73/86
Log-likelihod	-619.42	-544.87	-618.64	-578.83	-580.65	-576.53	-575.05	-576.37	-565.07	-574.16
Pseudo-R²	0.005	0.006	0.006	2.03	1.73	2.42	2.67	2.45	4.36	2.82
Wald Test (Prob H_o accepted)	4.80 (0.308)	13.52 (0.035)	5.60 (0.347)	18.25 (0.002)	10.18 (0.070)	12.91 (0.074)	20.71 (0.008)	12.10 (0.072)	34.69 (0.001)	25.02 (0.015)
Rho (Prob Rho = 0 accepted)	0.428 (0.00)	0.414 (0.00)	0.427 (0.00)	0.370 (0.00)	0.399 (0.00)	0.343 (0.00)	0.339 (0.00)	0.338 (0.00)	0.326 (0.00)	0.325 (0.00)

See the notes to Table 8.1.

Table 8.3	**Sample 3 - 1981-1997**									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
GDP per capita growth	0.898 *** (2.64)		0.883 ** (2.03)	0.684 (1.60)	0.602 * (1.67)	0.591 * (1.63)	0.591 (1.56)	0.591 (1.47)	0.542 (1.53)	0.639 (1.47)
Population Growth	0.995 (0.35)	0.363 (0.14)	1.003 (0.44)	6.929 *** (2.58)						
Energy intensity growth	0.263 * (1.62)	0.193 (1.05)	0.247 * (1.73)	0.237 * (1.82)	0.202 (1.49)	0.242 (1.47)	0.242 (1.48)	0.244 (1.43)	0.213 (1.07)	0.258 (1.26)
Carbon intensity growth	0.100 (1.03)	0.082 (1.01)	0.088 (1.43)	0.096 (1.48)	0.084 (1.12)	0.091 (1.07)	0.091 (1.12)	0.089 (1.17)	0.086 (0.98)	0.099 (1.42)
Agriculture VA growth		0.107 (0.87)								
Industry VA growth		0.06 (0.45)								
Services VA growth		0.112 (0.71)								
Openness 1			-0.028 (-0.34)							
Openness 2				0.137 *** (2.54)	0.138 *** (3.60)	0.116 ** (2.24)	0.116 ** (2.36)	0.116 ** (1.89)	0.138 ** (2.37)	0.127 * (1.62)
Urban population growth					0.043 ** (2.12)					
Young population growth						-2.748 (-1.23)	-2.749 (-1.09)	-2.695 (-1.36)	-3.297 (-1.38)	-2.931 (1.04)
Active population growth						10.910 *** (3.17)	10.912 *** (3.48)	10.977 ** (3.52)	9.353 *** (2.86)	11.459 *** (3.19)
Old population growth						0.491 (0.22)	0.489 (0.21)	0.497 (0.24)	-0.132 (-0.05)	0.626 (0.28)
Oil price growth							0.001 (0.03)			
Kyoto Protocol								0.104 (0.37)		
Protocol-1									0.176 (0.56)	
Protocol-2									-0.024 (-0.08)	
Environmental consciousness										-0.003 (-0.27)
Observations/Groups	1055/83/76	930/77/69	1044/82/75	1008/79/71	997/78/70	997/78/70	997/78/70	997/78/70	997/78/70	997/78/70
Log-likelihod	-446.18	-405.98	-438.33	-409.58	-407.08	-386.63	-386.63	-386.07	-381.29	-386.49
Pseudo-R^2	1.36	0.006	1.44	4.89	3.78	8.61	8.61	8.74	9.87	8.65
Wald Test (Prob H_o accepted)	4.97 (0.290)	2.47 (0.872)	5.44 (0.360)	19.20 (0.002)	17.47 (0.004)	13.31 (0.065)	30.00 (0.002)	23.92 (0.0024)	36.56 (0/000)	18.97 (0.015)
Rho (Prob Rho = 0 accepted)	0.567 (0.00)	0.573 (0.00)	0.571 (0.00)	0.508 (0.00)	0.528 (0.00)	0.484 (0.00)	0.484 (0.00)	0.474 (0.00)	0.477 (0.00)	0.485 (0.00)

See the notes to Table 8.1.

Appendix 9: Predicting degrowth episodes while taking into account heterogeneity

Table 9.1	**Sample 1 - 1966-1997**									
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
GDP per capita growth	-0.354***		-0.362***	-0.405 ***	-0.346***	-0.387 ***	-0.422 ***	-0.423 ***	-0.431 ***	-0.447 ***
	(-3.71)		(-3.20)	(-3.70)	(-2.95)	(-3.46)	(-2.99)	(-2.98)	(-3.10)	(-3.68)
Population Growth	-0.681	-0.017	-0.663	-3.823 ***			-2.941 *	-3.042	-2.822	-3.247 **
	(-0.43)	(-0.02)	(-0.52)	(-2.72)			(-1.80)	(-1.58)	(-1.29)	(-2.22)
Energy intensity growth	-0.249***	-0.119 *	-0.255***	-0.213	-0.158 *	-0.191	-0.214	-0.198	-0.201	-0.207
	(-2.77)	(-1.82)	(-2.80)	(-1.50)	(-1.67)	(-1.59)	(-1.48)	(-1.86)	(-1.41)	(-1.58)
Carbon intensity growth	-0.084**	-0.053	-0.086 *	-0.104	-0.085	-0.106**	-0.099 **	-0.097	-0.099	-0.098
	(-2.03)	(-1.46)	(-1.83)	(-1.52)	(-1.28)	(-2.15)	(-1.65)	(-1.17)	(-1.48)	(-1.45)
Agriculture VA growth		0.0182								
		(-0.61)								
Industry VA growth		-0.119 **								
		(-2.20)								
Services VA growth		-0.003								
		(-0.06)								
Openness 1			0.001							
			(0.06)							
Openness 2				-0.035						
				(-1.34)						
Urban population growth					-0.027 ***					
					(-2.69)					
Young population growth						0.651				
						(-0.88)				
Active population growth						-1.387				
						(-1.04)				
Old population growth						-0.971*				
						(-1.71)				
Oil price growth							-0.014			
							(-1.55)			
Kyoto Protocol								0.005		
								(0.15)		
Protocol-1									0.001	
									(0.00)	
Protocol-2									0.01	
									(0.03)	
Environmental consciousness										-0.002
										(-0.65)
Observations/Groups/Episodes	1398/48/27	1127/47/23	1366/47/26	1378/47/25	1346/46/25	1346/46/25	1378/47/25	1378/47/25	1378/47/25	1378/47/25
Log-likelihod	-270.82	-211.51	-269.77	-248.08	-242.53	-248.24	-249.40	-250.48	-250.48	-250.04
Pseudo-R²	3.12	2.21	3.23	6.64	8.20	6.25	5.75	5.40	5.45	5.62
Wald Test (Prob H_o accepted)	17.53 (0.001)	7.51 (0.276)	10.54 (0.061)	14.36 (0.013)	17.93 (0.001)	22.13 (0.001)	22.75 (0.009)	18.04 (0.00)	13.74 (0.01)	19.31 (0.001)
Rho (Prob Rho = 0 accepted)	0.403 (0.00)	0.577 (0.00)	0.394 (0.00)	0.319 (0.00)	0.368 (0.00)	0.324 (0.00)	0.331 (0.00)	0.326 (0.00)	0.328 (0.00)	0.327 (0.00)

Note: Estimated by Probit with specific country random effects. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistic. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10 % (*).

Table 9.2 **Sample 2 - 1972-1997**

	(1)	(2)	(3a)	(3b)	(4a)	(4b)	(5)	(6a)	(6b)	(6c)
GDP per capita growth	-0.298 ***		-0.301 ***	-0.246 ***	-0.216 **	-0.244 **	-0.242 **	-0.250 **	-0.333 **	-0.268 ***
	(-3.18)		(-2.90)	(-3.29)	(-2.18)	(-2.44)	(-2.19)	(-2.12)	(-2.33)	(-2.84)
Population Growth	-0.528	-0.204	-0.526	-0.762			-0.758 *	-0.767	-0.471	-0.756
	(-1.29)	(-0.41)	(-1.20)	(-1.03)			(-1.70)	(-1.40)	(-0.72)	(-1.35)
Energy intensity growth	-0.108 **	0.012	-0.111 **	-0.076	-0.045	-0.075	-0.078	-0.074	-0.09	-0.0802
	(-1.96)	(-0.23)	(-2.03)	(-1.11)	(-0.68)	(-1.07)	(-1.25)	(-1.09)	(-0.90)	(-1.17)
Carbon intensity growth	-0.047 *	-0.034	-0.046 *	-0.050 **	-0.045 **	-0.049 **	-0.054 ***	-0.050 **	-0.059 *	-0.048 **
	(-1.78)	(-1.54)	(-1.88)	(-2.07)	(-2.13)	(-2.07)	(-2.60)	(-2.32)	(-1.82)	(-2.18)
Agriculture VA growth		-0.002								
		(-0.06)								
Industry VA growth		-0.025								
		(-0.81)								
Services VA growth		0.005								
		(0.12)								
Openness 1			0.004							
			(0.17)							
Openness 2				-0.038 **	-0.041 **	-0.042 **	-0.041 **	-0.038 **	-0.059 *	-0.024
				(-2.10)	(-1.94)	(-2.24)	(-2.49)	(-2.23)	(-1.93)	(-1.31)
Urban population growth					-0.005					
					(-0.74)					
Young population growth						-0.507				
						(-0.92)				
Active population growth						-0.201				
						(-0.38)				
Old population growth						-0.120				
						(-0.37)				
Oil price growth							-0.009 *			
							(-1.86)			
Kyoto Protocol								0.012		
								(0.08)		
Protocol-1									-0.05	
									(-0.01)	
Protocol-2									0.72	
									(-0.11)	
Environmental consciousness										-0.003
										(-1.36)
Observations/Groups/Episodes	1767/76/40	1503/71/30	1764/76/40	1705/73/38	1705/73/38	1705/73/38	1705/73/38	1705/73/38	1705/73/38	1705/73/38
Log-likelihod	-379.07	-290.45	-378.90	-351.17	-351.04	-349.35	-349.42	-351.07	-346.69	-348.91
Pseudo-R²	1.94	0.65	1.97	9.14	9.17	9.62	9.60	9.17	10.30	9.73
Wald Test (Prob H_o accepted)	28.03 (0.00)	2.07 (0.91)	14;27 (0.01)	32.49 (0.00)	24.32 (0.00)	24.80 (0 .00)	19.96 (0.00)	26.76 (0.00)	36.79 (0.00)	17.42 (0.00)
Rho(Prob Rho = 0 accepted)	0.470 (0.00)	0.571 (0.00)	0.466 (0.00)	0.501 (0.00)	0.548 (0.00)	0.507 (0.00)	0.510 (0.00)	0.501 (0.00)	0.476 (0.00)	0.487 (0.00)

See the notes to Table 9.1.

Table 9.3	Sample 3 - 1981-1997								
	(1)	**(2)**	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6')**	**(6'')**
GDP per capita growth	-0.021 (-1.24)		-0.021 (-1.19)	-0.048 (-1.09)	-0.05 (-1.33)	-0.036 (-0.55)	-0.048 (-1.13)	-0.132 (-1.40)	-0.049 (-1.34)
Population Growth	-0.079 (-0.70)	0.009 (0.23)	-0.082 (-1.02)	-0.326 (-1.08)			-0.334 (-1.49)	0.006 (0.01)	-0.327 (-1.00)
Energy intensity growth	-0.005 (-0.71)	-0.003 (-0.22)	-0.005 (-0.79)	-0.015 (-0.87)	-0.014 (-0.78)	-0.018 (-0.83)	-0.016 (-1.47)	-0.024 (-0.70)	-0.014 (-0.70)
Carbon intensity growth	-0.009 (-1.48)	-0.002 * (-1.77)	-0.009 ** (-2.37)	-0.025 ** (-2.04)	-0.02 ** (-1.95)	-0.035 *** (-2.44)	-0.026 *** (-2.86)	-0.045 ** (-2.44)	-0.024 ** (-2.06)
Agriculture VA growth		0.002 (0.64)							
Industry VA growth		-0.03 (-1.15)							
Services VA growth		-0.0002 (-0.05)							
Openness 1			0.0001 (0.001)						
Openness 2				-0.021 * (-1.89)	-0.023 ** (-1.94)	-0.309 * (-1.82)	-0.023 ** (-1.97)	-0.049 ** (-1.99)	-0.191 ** (-2.23)
Urban population growth					-0.002 (-0.81)				
Young population growth						0.508 (1.39)			
Active population growth						-1.489 *** (-2.65)			
Old population growth						0.417 ** (1.98)			
Oil price growth							0.006 (1.11)		
Protocol-1								-0.071 ** (-2.33)	
Environmental consciousness									-0.022 (-0.18)
Observations/Groups	1218/83/26	1081/77/19	1201/82/26	1168/79/23	1151/78/23	1151/78/23	1168/79/23	1103/75/23	1168/79/23
Log-likelihod	-201.11	-150.17	-200.73	-180.84	-180.54	-167.46	-180.48	-174.50	-180.77
Pseudo-R²	1.50	2.83	1.52	4.22	4.22	11.16	4.41	6.91	4.26
Wald Test (Prob H_o accepted)	7.01 (0.13)	6.48 (0.26)	4.02 (0.55)	17.57 (0.00)	8.17 (0.15)	32.35 (0.00)	19.87 (0.00)	18.16 (0.00)	11 (0.08)
Rho (Prob Rho = 0 accepted)	0.758 (0.00)	0.791 (0.00)	0.756 (0.00)	0.663 (0.00)	0.676 (0.00)	0.689 (0.00)	0.664 (0.00)	0.624 (0.00)	0.661 (0.00)

See the notes to Table 9.1.

Appendix 10: The indexes of democratic political rights and civil liberties

(i) The Vanhanen's measure

Index of democratization = [(Index of Competition) x (Index of Participation)] / 100

with Index of Competition: 100 - the percentage of votes won by the largest party in parliamentary and/or presidential election.
Index of Participation: the percentage of total population which actually voted in the same election.

Source: Vanhanen, 2000.

(ii) The Polity IV index of Marshall and Jaggers

Polity Score = Democracy - Autocracy

with - Democracy is an additive eleven-point scale (0 to 10) derived from four essential elements:

a- Competitiveness of Executive Recruitment
Election (+2)
Transitional (+1)
b- Openness of Executive Recruitment only if (a) is Election or Transitional
Dual/election (+1)
Election (+1)
c- Constraint on Chief Executive
Executive parity or subordination (+4)
Intermediate category (+3)
Substantial limitations (+2)
Intermediate category (+1)
d- Competitiveness of Political Participation
Competitive (+3)
Transitional (+2)
Factional (+1)

- Autocracy is an additive eleven-point scale (0 to 10) derived from five essential elements:

a- Competitiveness of Executive Recruitment
Selection (+2)
b- Openness of Executive Recruitment only if (a) is coded Selection
Closed (+1)
Dual/designation (+1)
c- Constraints on Chief Executive
Unlimited authority (+3)
Intermediate category (+2)
Slight to moderate limitations (+1)
d- Regulation of participation
Restricted (+2)
Sectarian (+1)
e- Competitiveness of Participation
Repressed (+2)
Suppressed (+1)

Source: Marshall and Jaggers, 2007

Appendix 11: Predicting accelerations episodes with a two-step Probit model with random effects

Table 11.1	Sample 1 - 1966-1997								
	(1)	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
Observations/Groups/Episodes	1200/48/55	1174/47/47	1181/47/47	1174/47/47	1174/47/47	1200/48/55	1200/48/55	1200/48/55	1200/48/55
1st Stage									
Lagged GDP per capita	-0.031 ***	-0.028 ***	-0.0308 ***	-0.0307 ***	-0.0298 ***	-0.0309 ***	-0.0303 ***	-0.0312 ***	-0.0301 ***
	(-7.19)	(-6.71)	(-9.84)	(-6.22)	(-7.00)	(-7.22)	(-7.29)	(-7.16)	(-7.27)
Life expectancy at birth	0.0017 ***	0.0015 ***	0.0017 ***	0.002 ***	0.0017 ***	0.0017 ***	0.0017 ***	0.0015 ***	0.0024 ***
	(3.46)	(3.11)	(4.01)	(5.08)	(3.34)	(3.41)	(3.56)	(2.92)	(4.68)
R^2 (ΔR^2 from instruments)	19.72 (0.868)	19.50 (0.645)	19.57 (1.398)	18.45 (0.700)	19.44 (0.745)	19.68 (0.864)	20.92 (0.789)	20.69 (0.645)	22.29 (0.673)
F-Stat on joint significance of instruments (Prob H_o accepted)	83.09 (0.00)	75.85 (0.00)	107.80 (0.00)	39.36 (0.00)	81.35 (0.00)	84.34 (0.00)	83.91 (0.00)	60.91 (0.00)	57.47 (0.00)
2nd Stage									
GDP per capita growth	-0.974	-1.18	-1.43	0.335	-0.493	-0.816	-0.967	-2.329	-0.579
	(-0.61)	(-0.54)	(-0.80)	(0.21)	(-0.29)	(-0.55)	(-0.53)	(-1.15)	(-0.27)
Population Growth	-1.1332	-1.498	2.06			-1.19	-1.33	-4.076	-1.082
	(-0.50)	(-0.63)	(0.60)			(-0.44)	(-0.47)	(-1.17)	(-0.34)
Energy intensity growth	0.105	0.002	-0.02	0.395	0.227	0.163	0.110	-0.322	0.278
	(0.19)	(0.00)	(-0.04)	(0.68)	(0.39)	(0.32)	(0.19)	(-0.47)	(0.33)
Carbon intensity growth	0.265 *	0.224	0.266 **	0.281 *	0.277 *	0.276 *	0.266	0.168	0.294
	(1.84)	(1.12)	(2.35)	(1.74)	(1.79)	(1.90)	(1.55)	(0.95)	(1.55)
Openness 1		-0.139							
		(-0.96)							
Openness 2			0.048						
			(0.97)						
Urban population growth				-0.003					
				(-0.20)					
Young population growth					-1.001				
					(-0.71)				
Active population growth					-0.617				
					(-0.28)				
Old population growth					0.788				
					(0.44)				
Oil price growth						-0.032			
						(-1.32)			
Kyoto Protocol							0.021		
							(0.06)		
Protocol-1								0.149	
								(0.59)	
Protocol-2								-0.139	
								(-0.61)	
Environmental consciousness									0.001
									(0.16)
Resid from 1st Stage	1.19	1.388	1.621	-0.997	0.702	1.021	1.17	2.62	0.784
	(0.70)	(0.61)	(0.88)	(-0.06)	(0.40)	(0.68)	(0.63)	(1.25)	(0.35)
Log-likelihod	-388.41	-377.08	-375.72	-381.13	-377.51	-386.73	-388.35	-377.01	-388.32
Pseudo-R^2	1.96	2.21	1.37	1.16	2.10	2.39	1.98	4.84	1.99
Wald Test (Prob H_o accepted)	19.14 (0.00)	15.01 (0.02)	13.74 (0.03)	21.23 (0.00)	15.15 (0.03)	14.13 (0.03)	14.46 (0.02)	26.64 (0.00)	14.99 (0.02)
Rho (Prob Rho = 0 accepted)	0.587 (0.00)	0.598 (0.00)	0.544 (0.00)	0.558 (0.00)	0.596 (0.00)	0.583 (0.00)	0.583 (0.00)	0.505 (0.00)	0.570 (0.00)

Notes: Estimated by two-stage Probit model with country random effects. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistic. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10 % (*).

Table 11.2 — **Sample 2 - 1972-1997**

	(1)	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
Observations/Groups/Episodes	1480/76/91	1477/76/91	1429/73/86	1429/73/86	1429/73/86	1429/73/86	1429/73/86	1429/73/86	1429/73/86
1st Stage									
Lagged GDP per capita	-0.014 ***	-0.015 ***	-0.013 ***	-0.010 ***	-0.014 ***	-0.014 ***	-0.015 ***	-0.015 ***	-0.015 ***
	(-3.44)	(-3.63)	(-3.89)	(-2.84)	(-3.96)	(-3.94)	(-4.13)	(-4.27)	(-4.19)
Life expectancy at birth	0.001 ***	0.001 ***	0.001 ***	0.001 ***	0.001 ***	0.001 ***	0.001 ***	0.001 ***	0.001 ***
	(2.98)	(2.69)	(2.78)	(3.79)	(2.99)	(3.07)	(3.15)	(3.15)	(3.58)
R^2 (ΔR^2 from instruments)	27.63 (0.055)	28.34 (0.050)	31.88 (0.048)	32.95 (0.066)	31.99 (0.043)	32.38 (0.044)	32.06 (0.045)	32.08 (0.040)	33.29 (0.048)
F-Stat on joint significance of instruments (Prob H_o accepted)	11.86 (.00)	14.10 (0.00)	15.16 (0.00)	15.28 (0.00)	15.69 (0.00)	15.52 (0.00)	17.09 (0.00)	18.27 (0.00)	17.83 (0.00)
2nd Stage									
GDP per capita growth	8.127 *	7.468 *	6.623	5.31	5.690	5.629	5.353	1.810	4.841
	(1.77)	(1.69)	(1.55)	(1.47)	(1.23)	(1.30)	(1.38)	(0.53)	(1.28)
Population Growth	4.058	3.892	5.341 *						
	(1.53)	(1.32)	(1.90)						
Energy intensity growth	2.844 *	2.654 *	2.651	2.079	2.29	2.246	2.169	0.701	1.945
	(1.76)	(1.71)	(1.55)	(0.48)	(1.24)	(1.30)	(1.40)	(0.53)	(1.31)
Carbon intensity growth	0.288 **	0.264 **	0.039	0.049	0.037	0.035	0.037	0.040	0.024
	(2.22)	(2.25)	(0.36)	(0.74)	(0.43)	(0.41)	(0.48)	(0.53)	(0.32)
Openness 1		-0.151							
		(-1.40)							
Openness 2			-0.007	-0.0003	-0.004	0.0003	0.0101	0.094 *	-0.029
			(-0.11)	(-0.001)	(0.06)	(0.00)	(0.14)	(1.63)	(-0.31)
Urban population growth				0.011					
				(0.45)					
Young population growth					0.167	0.326	0.198	-0.033	0.409
					(0.10)	(0.15)	(0.10)	(-0.02)	(0.19)
Active population growth					6.154 **	6.111 **	6.128 ***	3.170	6.242 *
					(2.49)	(2.24)	(2.50)	(1.21)	(2.31)
Old population growth					-1.367	-1.361	-1.303	-1.067	-1.676
					(-0.68)	(-0.81)	(-0.56)	(-0.61)	(-0.86)
Oil price growth						-0.057 **			
						(-2.09)			
Kyoto Protocol							0.054		
							(0.13)		
Protocol-1								0.111	
								(0.47)	
Protocol-2								-0.110	
								(-0.45)	
Environmental consciousness									0.021**
									(1.96)
Resid from 1st Stage	-7.68 *	-7.03	-6.260	-5.01	-5.294	-5.185	-4.95	-1.454	-4.378
	(-1.66)	(-1.58)	(-1.42)	(-1.37)	(-1.15)	(-1.19)	(-1.25)	(-0.43)	(-1.15)
Log-likelihod	-615.11	-614.63	-576.02	-578.91	-574.24	-572.83	-574.22	-564.89	-572.34
Pseudo-R^2	1.22	1.21	2.51	2.02	2.81	3.05	2.81	4.39	3.13
Wald Test (Prob H_o accepted)	8.64 (0.12)	11.42 (0.08)	18.19 (0.01)	14.84 (0.02)	18.24 (0.02)	18.80 (0.03)	18.91 (0.03)	34.91 (0.00)	20.26 (0.02)
Rho (Prob Rho = 0 accepted)	0.432 (0.00)	0.421 (0.00)	0.337 (0.00)	0.395 (0.00)	0.322 (0.00)	0.320 (0.00)	0.321 (0.00)	0.323 (0.00)	0.12 (0.00)

See the notes to Table 11.1

Table 11.3	**Sample 3 - 1981-1997**								
	(1)	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
Observations/Groups/Episodes	1055/83/76	1044/82/75	1008/79/71	997/78/70	997/78/70	997/78/70	997/78/70	997/78/70	997/78/70
1st Stage									
Lagged GDP per capita	-0.018 ***	-0.017 ***	-0.018 ***	-0.016 ***	-0.017 ***	-0.017 ***	-0.017 ***	-0.014 ***	-0.017 ***
	(-3.99)	(-3.88)	(-4.25)	(-3.38)	(-3.71)	(-3.73)	(-3.74)	(-3.05)	(-3.67)
Life expectancy at birth	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***
	(4.93)	(4.82)	(4.50)	(4.73)	(4.35)	(4.36)	(4.69)	(4.60)	(4.28)
R^2 (ΔR^2 from instruments)	24.86 (0.254)	25 (0.230)	25.22 (0.211)	24.92 (0.214)	24.77 (0.165)	24.78 (0.164)	24.77 (0.158)	25.22 (0.150)	24.77 (0.166)
F-Stat on joint significance of instruments (Prob H_o accepted)	24.85 (0.00)	2.77 (0.00)	22.69 (0.00)	22.35 (0.00)	19.46 (0.00)	19.63 (0.00)	22.69 (0.00)	21.25 (0.00)	18.83 (0.00)
2nd Stage									
GDP per capita growth	8.08 **	8.504 **	6.94 **	6.781 **	4.865	4.893	4.597	3.757	5.141
	(2.36)	(2.07)	(2.14)	(2.16)	(1.54)	(1.55)	(1.39)	(0.93)	(1.35)
Population Growth	4.373	4.594	7.679 ***						
	(1.24)	(1.20)	(3.08)						
Energy intensity growth	1.679 **	1.745 **	1.443 **	1.396 **	1.065 *	1.069 *	1.015	0.832	1.116
	(2.28)	(2.11)	(2.26)	(2.29)	(1.71)	(1.78)	(1.52)	(1.04)	(1.40)
Carbon intensity growth	0.443 **	0.448 ***	0.361 **	0.346 ***	0.271 *	0.273 *	0.258	0.220	0.285
	(2.26)	(2.61)	(2.17)	(2.86)	(1.70)	(1.69)	(1.44)	(1.13)	(1.45)
Openness 1		-0.045							
		(-0.43)							
Openness 2			-0.012	-0.006	0.025	0.025	0.031	0.057	0.031
			(-0.12)	(-0.06)	(0.29)	(0.29)	(0.33)	(0.58)	(0.36)
Urban population growth				0.044 *					
				(1.77)					
Young population growth					-2.00	-1.99	-2.019	-2.484	-1.99
					(-0.93)	(-0.87)	(-0.75)	(-0.83)	(-0.84)
Active population growth					10.81 ***	10.783 ***	10.893 ***	9.068 ***	10.636 ***
					(3.88)	(3.52)	(3.29)	(2.85)	(3.46)
Old population growth					0.331	0.379	0.395	-0.114	0.514
					(0.18)	(0.19)	(0.16)	(-0.05)	(0.24)
Oil price growth						-0.015			
						(-0.37)			
Kyoto Protocol							0.084		
							(0.22)		
Protocol-1								0.131	
								(0.36)	
Protocol-2								-0.036	
								(-0.10)	
Environmental consciousness									-0.004
									(-0.39)
Resid from 1st Stage	-7.332 **	-7.747 *	-6.301 *	-6.231 *	-4.281	-4.309	-4.012	-3.247	-4.539
	(-2.04)	(-1.79)	(-1.85)	(-1.93)	(-1.34)	(-1.35)	(-1.14)	(-0.79)	(-1.14)
Log-likelihod	-440.24	-432.42	-405.31	-402.95	-384.74	-384.73	-384.45	-380.18	-384.42
Pseudo-R^2	2.68	2.77	5.88	4.75	9.06	9.06	9.13	10.14	9.13
Wald Test (Prob H_o accepted)	14.11 (0.01)	15.67 (0.02)	21.07 (0.02)	22.82 (0.00)	30.90 (0.00)	35.60 (0.00)	26.86 (0.01)	32.76 (0.00)	22.72 (0.07)
Rho (Prob Rho = 0 accepted)	0.580 (0.00)	0.586 (0.00)	0.478 (0.00)	0.498 (0.00)	0.469 (0.00)	0.469 (0.00)	0.463 (0.00)	0.469 (0.00)	0.471 (0.00)

See the notes to Table 11.1

Appendix 12: Predicting degrowth episodes with a two-step Probit model with random effects

Table 12.1	Sample 1 - 1966-1997								
	(1)	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
Observations/Groups/Episodes	1398/48/27	1366/47/26	1378/47/25	1346/46/25	1346/46/25	1378/47/25	1378/47/25	1378/47/25	1378/47/25
1st Stage									
Lagged GDP per capita	-0.029 ***	-0.028 ***	-0.023 ***	-0.025 ***	-0.024 ***	-0.028 ***	-0.027 ***	-0.029 ***	-0.027 ***
	(-8.52)	(-7.99)	(-10.71)	(-7.20)	(-7.78)	(-8.74)	(-8.82)	(-9.14)	(-8.72)
Life expectancy at birth	0.001***	0.001 **	not significant	0.001***	0.001 *	0.001 **	0.001 **	0.001 **	0.001 **
	(2.85)	(2.47)		(3.65)	(1.87)	(2.26)	(2.42)	(2.34)	(2.99)
R^2 (ΔR^2 from instruments)	19.25 (1.25)	19.05 (1.10)	20.67 (1.55)	14.06 (0.69)	15.84 (1.06)	15.68 (1.58)	17.10 (1.43)	17.33 (1.41)	16.81 (1.24)
F-Stat on joint significance of instruments (Prob H_o accepted)	95.85 (0.00)	89.28 (0.00)	x	54.41 (0.00)	82.94 (0.00)	98.42 (0.00)	98.65 (0.00)	106.27 (0.00)	85.49 (0.00)
2nd Stage									
GDP per capita growth	-3.025 ***	-3.173 ***	-2.387 ***	-2.887 **	-2.541 **	-2.279 **	-2.562 **	-2.393 **	-4.299 ***
	(-4.07)	(-3.91)	(-2.61)	(-2.03)	(-2.13)	(-2.20)	(-2.00)	(-2.23)	(-2.84)
Population Growth	-2.156 *	-2.235 *	-4.035 ***			-3.276 ***	-3.538 *	-3.287	-5.008 **
	(-1.78)	(-1.63)	(-2.91)			(-2.84)	(-1.83)	(-1.58)	(-2.12)
Energy intensity growth	-0.908 ***	-0.944 ***	-0.647 **	-0.703 **	-0.633 *	-0.598 **	-0.639 **	-0.603 **	-1.034 ***
	(-3.44)	(-3.67)	(-2.29)	(-1.92)	(-1.78)	(-1.99)	(-2.24)	(-2.01)	(-2.73)
Carbon intensity growth	-0.184 ***	-0.187 ***	-0.164 ***	-0.158 *	-0.156 *	-0.149 **	-0.153	-0.146 *	-0.200 **
	(-3.18)	(-3.18)	(-2.57)	(-1.87)	(-1.72)	(-2.21)	(-1.56)	(-1.93)	(-2.35)
Openness 1		-0.0009							
		(0.00)							
Openness 2			-0.017						
			(-0.64)						
Urban population growth				-0.022 *					
				(-1.73)					
Young population growth					-0.927				
					(-1.53)				
Active population growth					-1.825 *				
					(-1.78)				
Old population growth					-0.283				
					(-0.40)				
Oil price growth						-0.016			
						(-1.52)			
Kyoto Protocol							-0.011		
							(-0.05)		
Protocol-1								-0.007	
								(-0.02)	
Protocol-2								-0.003	
								(-0.01)	
Environmental consciousness									-0.010 *
									(-1.86)
Resid from 1st Stage	2.798 ***	2.937 ***	2.079 **	2.634 *	2.234 *	1.962 *	2.256 *	2.102 *	3.950 ***
	(3.53)	(3.42)	(2.14)	(1.73)	(1.77)	(1.83)	(1.74)	(1.85)	(2.55)
Log-likelihod	-257.72	-257.40	-242.12	-238.04	-243.91	-244.11	-244.31	-244.41	-239.63
Pseudo-R^2	7.80	7.66	8.61	10.10	7.88	7.86	7.78	7.74	9.55
Wald Test (Prob H_o accepted)	31.76 (0.00)	20.45 (0.00)	27.31 (0.00)	34.61 (0.00)	35.75 (0.00)	25.17 (0.00)	27.36 (0.00)	25.20 (0.00)	21.67 (0.00)
Rho (Prob Rho = 0 accepted)	0.440 (0.00)	0.430 (0.00)	0.341 (0.00)	0.473 (0.00)	0.413 (0.00)	0.418 (0.00)	0.427 (0.00)	0.418 (0.00)	0.488 (0.00)

Notes: Estimated by two-stage Probit model with country random effects. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistic. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10 % (*).

Table 12.2	**Sample 2 - 1972-1997**								
	(1)	**(3a)**	**(3b)**	**(4a)**	**(4b)**	**(5)**	**(6a)**	**(6b)**	**(6c)**
Observations/Groups/Episodes	1767/76/40	1764/76/40	1705/73/38	1705/73/38	1705/73/38	1705/73/38	1705/73/38	1705/73/38	1705/73/38
1st Stage									
Lagged GDP per capita	-0.013 *** (-4.13)	-0.014 *** (-4.39)	-0.011 *** (-5.17)	-0.010 *** (-3.08)	-0.014 *** (-4.56)	-0.013 *** (-4.51)	-0.014 *** (-4.76)	-0.014 *** (-4.81)	-0.014 *** (-4.75)
Life expectancy at birth	0.001 ** (2.81)	0.001 *** (2.52)	not significant	0.01 ** (2.44)	0.0006 * (1.63)	0.0005 * (1.72)	0.0005 * (1.63)	0.0005 * (1.69)	0.001 ** (2.10)
R^2 (ΔR^2 from instruments)	29.44 (0.04)	30.42 (0.03)	30.30 (0.03)	30.75 (0.04)	30.73 (0.05)	31.03 (0.05)	30.99 (0.06)	31.01 (0.03)	31.73 (0.06)
F-Stat on joint significance of instruments (Prob H_o accepted)	17.42 (0.00)	21.02 (0.00)	x	10.43 (0.00)	29.18 (0.00)	26.71 (0.00)	29.60 (0.00)	27.76 (0.00)	27.11 (0.00)
2nd Stage									
GDP per capita growth	-3.04 * (-1.88)	-2.324 (-1.55)	-1.348 (-1.34)	-4.468 ** (-2.03)	-2.110 (-1.50)	-2.070 * (-1.63)	-2.147 * (-1.82)	-1.171 (-0.83)	-2.762 * (1.63)
Population Growth	-1.53 ** (-2.06)	-1.297 * (-1.65)	-1.218 * (-1.72)			-1.398 (-1.58)	-1.468 ** (-2.31)	-0.781 (-0.86)	-1.547 * (-2.33)
Energy intensity growth	-1.18 * (-1.92)	-0.912 (-1.52)	-0.505 (-1.24)	-1.705 ** (-2.05)	-0.802 (-1.55)	-0.789 (-1.59)	-0.814 * (-1.86)	-0.421 (-0.74)	-1.047 * (-1.62)
Carbon intensity growth	-0.03 (-1.45)	-0.039 (-1.57)	-0.051 * (-1.83)	-0.027 (-0.91)	-0.044 (-1.44)	-0.049 ** (-2.01)	-0.046 * (-1.83)	-0.053 (-1.51)	-0.035 (-1.30)
Openness 1		0.030 (0.95)							
Openness 2			-0.026 (-1.46)	0.020 * (0.480)	-0.022 (-1.19)	-0.019 (-0.97)	-0.018 (-1.03)	-0.045 (-1.24)	0.012 (0.37)
Urban population growth				0.005 (0.42)					
Young population growth					-0.685 (-1.28)				
Active population growth					-0.885 (-1.11)				
Old population growth					-0.128 (-0.21)				
Oil price growth						-0.004 (-0.48)			
Kyoto Protocol							0.011 (0.06)		
Protocol-1								-0.004 (-0.02)	
Protocol-2								0.057 (0.17)	
Environmental consciousness									-0.009 * (-1.92)
Resid from 1st Stage	2.770 * (1.70)	2.045 (1.34)	1.072 (1.08)	4.222 ** (1.95)	1.845 (1.36)	1.813 (1.40)	1.874 (1.57)	0.852 (0.61)	2.467 1.44
Log-likelihod	-375.25	-376.30	-350.34	-346.54	-347.08	-347.48	-348.73	-346.38	-345.52
Pseudo-R^2	2.92	2.64	4.44	5.47	5.33	5.22	4.88	5.52	5.75
Wald Test (Prob H_o accepted)	16.50 (0.00)	16.06 (0.00)	28.43 (0.00)	17.74 (0.00)	20.51 (0.00)	28.08 (0.00)	66.97 (0.00)	30.33 (0.00)	23.57 (0.00)
Rho (Prob Rho = 0 accepted)	0.501 (0.00)	0.497 (0.00)	0.509 (0.00)	0.559 (0.00)	0.532 (0.00)	0.521 (0.00)	0.516 (0.00)	0.488 (0.00)	0.531 (0.00)

See the notes to Table 12.1

Table 12.3 — Sample 3 - 1981-1997

	(1)	(3a)	(3b)	(4a)	(4b)	(5)	(6')	(6'')
Observations/Groups/Episodes	1218/83/26	1201/82/26	1168/79/23	1151/78/23	1151/78/23	1168/79/23	1103/75/23	1168/79/23
1st Stage								
Lagged GDP per capita	-0.025 *** (-5.41)	-0.024 *** (-5.32)	-0.022 *** (-5.80)	-0.020 *** (-4.43)	-0.019 *** (-4.49)	-0.022 *** (-5.48)	-0.020 *** (-4.29)	-0.022 *** (-5.50)
Life expectancy at birth	0.003 *** (5.15)	0.003 *** (5.03)	0.002 *** (3.87)	0.002 *** (4.16)	0.002 *** (3.41)	0.002 *** (3.85)	0.002 *** (4.10)	0.002 *** (3.85)
R^2 (ΔR^2 from instruments)	24.37 (0.35)	24.07 (0.34)	26.86 (0.25)	25.46 (0.25)	26.72 (0.16)	26.91 (0.25)	23.45 (0.22)	26.87 (0.25)
F-Stat on joint significance of instruments (Prob H_o accepted)	31.42 (0.00)	30.22 (0.00)	30.27(0.00)	21.14 (0.0)	20.21 (0.00)	29.99 (0.00)	20.99 (0.22)	30.23 (0.00)
2nd Stage								
GDP per capita growth	-0.303 (-1.32)	-0.312 (-1.43)	-0.286 (-0.82)	-0.384 (-0.82)	0.084 (0.13)	-0.289 (-0.76)	-0.463 (-0.61)	-0.281 (-0.86)
Population Growth	-0.269 (-1.11)	-0.277 (-1.15)	-0.432 (-1.21)			-0.441 (-1.26)	-0.296 (-0.41)	-0.433 (-1.16)
Energy intensity growth	-0.062 (-1.24)	-0.064 (-1.27)	-0.064 (-0.81)	-0.082 (-0.81)	0.006 (0.04)	-0.065 (-0.83)	-0.069 (-0.55)	-0.062 (-0.89)
Carbon intensity growth	-0.028 * (-1.74)	-0.028 * (-1.82)	-0.039 * (-1.84)	-0.044 (-1.58)	-0.032 (-1.12)	-0.046 * (-1.66)	-0.049 (-1.58)	-0.038 * (-1.85)
Openness 1		0.0009 (0.00)						
Openness 2			-0.010 (-1.05)	-0.012 (-1.26)	-0.028 * (-1.87)	-0.011 (-1.33)	-0.036 (-1.14)	-0.010 (-1.19)
Urban population growth				-0.004 (-1.19)				
Young population growth					0.59 (-1.41)			
Active population growth					-1.601 *** (-3.07)			
Old population growth					0.438 * (1.71)			
Oil price growth						0.008 (1.42)		
Protocol-1							-0.058 *** (-2.62)	
Environmental consciousness								-0.0003 (-0.19)
Resid from 1st Stage	0.280 (1.17)	0.288 (1.25)	0.238 (0.66)	0.328 (0.70)	-0.124 (-0.20)	0.241 (0.63)	0.353 (0.45)	0.232 (0.68)
Log-likelihod	-199.51	-199.22	-180.46	-180.11	-167.45	-180.09	-174.28	-180.40
Pseudo-R^2	2.28	2.27	4.42	4.44	11.16	4.46	7.07	4.45
Wald Test (Prob H_o accepted)	0.727 (0.00)	0.726 (0.00)	0.659 (0.00)	0.654 (0.00)	0.689 (0.00)	0.661 (0.00)	0.619 (0.00)	0.658 (0.00)
Rho (Prob Rho = 0 accepted)	4.81 (0.44)	6.58 (0.36)	12.65 (0.05)	14.9 (0.02)	28.43 (0.00)	14.52 (0.04)	27.46 (0.00)	14.45 (0.04)

See the notes to Table 12.1

Appendix 13: Predicting both accelerations growth episodes and degrowth episodes in a multinomial logit model

Table 13.1	**Sample 1 - 1966-1997**																			
	(1)		**(2)**		**(3a)**		**(3b)**		**(4a)**		**(4b)**		**(5)**		**(6a)**		**(6b)**		**(6c)**	
	A	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**
gGDP	0.01	-0.79***			0.04	-0.77***	-0.04	-0.67***	-0.25	-0.54***	-0.02	-0.62***	-0.01	-0.62***	-0.02	-0.63***	0.06	-0.62***	0.07	-0.64***
	(-0.42)	(-4.92)			(-0.28)	(-4.57)	(-0.45)	(-4.20)	(-1.11)	(-2.98)	(-0.34)	(-3.47)	(-0.30)	(-3.48)	(-0.35)	(-3.46)	(-0.49)	(-3.44)	(-0.01)	(-3.43)
gPOP	2.06	-4.43	1.79	-0.05	2.13	-0.40	7.48***	-5.34***												
	(0.60)	(-0.98)	(0.44)	(0.35)	(0.59)	(-0.79)	(5.33)	(-4.00)												
gENER-INT	0.48	-0.46**	0.62**	-0.37	0.45	-0.46**	0.33	-0.35 *	0.26	-0.33	0.31	-035*	0.31	-0.38*	0.30	-0.35*	0.29	-0.35*	0.33	-0.36*
	(1.56)	(-2.14)	(1.92)	(-1.35)	(1.41)	(-2.08)	(1.16)	(-1.74)	(0.83)	(-1.52)	(1.04)	(-1.66)	(1.00)	(-1.77)	(1.02)	(-1.64)	(0.98)	(-1.64)	(1.13)	(-1.68)
gCARB-INT	0.39*	-0.15	0.35	-0.12	0.38*	-0.16	0.37*	-0.09	0.35	-0.07	0.36*	-0.01	0.36*	-0.11	0.36*	-0.11	0.36*	-0.11	0.35*	-0.11
	(1.81)	(-1.03)	(1.53)	(-0.73)	(1.74)	(-1.05)	(1.70)	(-0.43)	(1.55)	(-0.31)	(1.70)	(-0.55)	(1.72)	(-0.54)	(1.72)	-0.56	(1.69)	(-0.56)	(1.72)	(-0.53)
gVA-AGR			-0.12	0.05																
			(-0.90)	(0.37)																
gVA-IND			0.26	-0.41***																
			(1.04)	(-3.58)																
gVA-SERV			0.05	-0.12																
			(0.13)	(-0.67)																
Openness 1					-0.03	0.002														
					(-0.53)	(1.04)														
Openness 2							0.03	-0.05***	0.02	-0.07***	0.03	-0.05**	0.03	-0.05**	0.03	-0.05***	0.04	-0.05**	0.02	-0.04**
							(1.03)	(-2.71)	(0.41)	(-3.42)	(1.05)	(-2.40)	(1.04)	(-2.44)	(1.16)	(-2.57)	(1.34)	(-2.37)	(0.63)	(-2.29)
gURB-POP									0.04***	-0.04***										
									(5.14)	(5.04)										
gPOP-y											0.61	-0.62	0.65	-0.60	0.65	-0.65	0.4	-0.65	0.71	-0.62
											(0.54)	(-1.24)	(0.59)	(-1.13)	(0.59)	(-1.25)	(0.33)	(-1.24)	(0.64)	(-1.23)
gPOP-a											5.96***	-3.03***	6***	-3.13***	6***	-3.12***	4.02**	-3.14***	6.06***	-3.06***
											(4.19)	(-2.98)	(4.19)	(-3.03)	(4.27)	(-3.04)	(2.24)	(-2.76)	(4.09)	(-3.02)
gPOP-r											0.91	-1.43***	0.93	-1.29**	0.93	-1.43***	0.69	-1.44***	0.76	-1.43**
											(0.69)	(-2.74)	(0.73)	(-2.45)	(0.72)	(-2.74)	(0.48)	(-2.72)	(0.54)	(-2.78)
gOIL													-0.04*	-0.02*						
													(-1.64)	(-1.72)						
Protocol															0.09*	-0.04				
															(1.83)	(-0.61)				
Protocol1																	0.18**	-0.03		
																	(2.08)	(-0.63)		
Protocol2																	0.09	-0.03		
																	(1.23)	(-0.57)		
Consciousness																			0.01**	-0.001
																			(2.15)	(-0.35)
Observations/Groups	1086/48		865/47		1060/47		1072/47		1046/46		1046/46		1046/46		1046/46		1046/46		1046/46	
Number of episodes	55-27		50-27		55-26		53-25		52-25		52-25		52-25		52-25		52-25		52-25	
Log-likelihod	-718.23		-604.07		-706.34		-660.01		-647.42		-644.67		-641.75		-642.09		-640.71		-642.53	
Pseudo-R²	2.23		2.32		2.31		6.51		6.78		7.18		7.60		7.55		7.75		7.49	

Note: Estimated by a multinomial Logit model where the dependent variable takes the value 2 if a degrowth episode occurs (column D), the value 1 if an acceleration episodes occurs (column A) and the value 0 otherwise. Coefficients shown are average partial effects, i.e the mean of national marginal effects. Numbers in parenthesis are robust t-statistics. Significance levels are indicated by asterisks in the following way: 1% (***), 5% (**) and 10% (*).

Table 13.2 **Sample 2 - 1972-1997**

	(1)		**(2)**		**(3a)**		**(3b)**		**(4a)**		**(4b)**		**(5)**		**(6a)**		**(6b)**		**(6c)**	
	A	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**
gGDP	0.28	-0.67***			0.29	-0.72***	0.28	-0.60***	0.04	-0.54***	0.28	-0.59***	0.33	-0.59***	0.28	-0.59***	0.18	-0.62***	0.35	-0.62***
	(0.49)	(-4.08)			(0.49)	(-4.19)	(0.62)	(-3.46)	(-0.27)	(-2.99)	(0.64)	(-3.29)	(0.80)	(-3.29)	(0.64)	(-3.29)	(0.27)	(-3.41)	(0.89)	(-3.41)
gPOP	4.47*	-0.98**	4.35	-0.64	4.55*	-1**	8.81***	-3.63***												
	(1.74)	(-2.52)	(1.39)	(-0.89)	(1.75)	(-2.63)	(7.47)	(-3.64)												
gENER-INT	0.15	-0.28**	0.07	0.01	0.16	-0.3**	0.07	-0.33***	0.01	-0.26**	0.10	-0.35***	0.11	-0.36***	0.11	-0.33***	0.06	-0.33**	0.12	-0.35***
	(0.44)	(-2.42)	(0.26)	(0.10)	(0.46)	(-2.51)	(0.05)	(-2.73)	(-0.25)	(-2.00)	(0.16)	(-2.84)	(0.19)	(-2.91)	(0.25)	(-2.63)	(-0.01)	(-2.55)	(0.27)	(-2.86)
gCARB-INT	0.09	-0.07	0.08	-0.08	0.09	-0.08	0.5	-0.04	0.04	-0.03	0.05	-0.05	0.04	-0.50	0.05	-0.05	0.03	-0.03	0.04	-0.05
	(0.86)	(-1.27)	(0.71)	(-0.92)	(0.84)	(-1.32)	(0.52)	(-0.57)	(0.40)	(-0.43)	(0.49)	(-0.61)	(0.44)	(0.63)	(0.45)	(-0.61)	(0.36)	(-0.45)	(0.36)	(-0.57)
gVA-AGR			-0.09	-0.02																
			(-0.84)	(-0.31)																
gVA-IND			0.27*	-0.14																
			(1.75)	(-1.43)																
gVA-SERV			-0.01	-0.16																
			(-0.24)	(-1.07)																
Openness 1					-0.04	0.04														
					(-0.78)	(1.26)														
Openness 2							0.06**	-0.08***	0.04	-0.06***	0.07**	-0.08***	0.07**	-0.08***	0.07**	-0.08***	0.09***	-0.10***	0.05	-0.07***
							(1.91)	(-4.38)	(1.26)	(-3.14)	(2.19)	(-4.09)	(2.06)	(-4.16)	(2.22)	(-4.05)	(3.17)	(-4.48)	(1.47)	(-3.50)
gURB-POP									0.50***	-0.01										
									(7.65)	(-0.85)										
gPOP-y											1.27	-0.38	1.28	-0.36	1.31	-0.37	0.99	-0.29	1.26	-0.36
											(1.43)	(-0.46)	(1.45)	(0.42)	(1.47)	(-0.42)	(1.14)	(-0.34)	(1.42)	(-0.41)
gPOP-a											8.13***	-2.48**	8.13**	-2.54**	8.15***	-2.45**	5.45***	-1.52	8.26***	-2.53***
											(6.39)	(-2.46)	(6.31)	(-2.51)	(6.44)	(-2.42)	(4.23)	(-1.40)	(6.33)	(-2.55)
gPOP-r											-1.35	-0.99**	-1.37*	-0.93**	-1.36*	-1.01**	-1.87**	-0.85**	-1.60*	-0.96**
											(-1.60)	(-2.13)	(1.62)	(-2.01)	(-1.62)	(2.14)	(-2.06)	(-2.03)	(-1.83)	(-2.05)
gOIL													-0.04*	-0.01						
													(-1.89)	(-1.56)						
Protocol															0.07*	0.02				
															(1.60)	(0.63)				
Protocol1																	0.11**	0.01		
																	(2.04)	(0.40)		
Protocol2																	-0.03	0.07		
																	(-0.38)	(1.03)		
Consciousness																			0.01***	-0.01*
																			(2.57)	(-1.62)
Observations/Groups	1317/76		1115/71		1314/76		1275/73		1275/73		1275/73		1275/73		1275/73		1275/73		1275/73	
Number of episodes	91-40		82-30		91-40		86-38		86-38		86-38		86-38		86-38		86-38		86-38	
Log-likelihod	-1017.90		-854.71		-1015.37		-938.97		-953.67		-929.19		-926.14		-927/75		-917.90		-924.52	
Pseudo-R²	2.24		1.98		2.39		5.77		4.29		6.75		7.06		6.90		7.88		7.22	

See the notes to Table 13.1.

Table 13.3 **Sample 3 - 1981-1997**

	(1)		**(2)**		**(3a)**		**(3b)**		**(4a)**		**(4b)**		**(5)**		**(6')**		**(6'')**	
	A	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**	**A**	**D**
gGDP	0.80*	-0.66***			0.79	-0.62***	0.83***	-0.33	0.57	-0.32	0.58	-0.29	0.58**	-0.29	0.71	-0.45*	0.61	-0.31
	(1.60)	(-3.28)			(1.58)	(-3.14)	(1.96)	(-1.45)	(1.44)	(-1.46)	(1.44)	(-1.33)	(1.96)	(-1.34)	(1.59)	(-1.89)	(1.48)	(1.42)
gPOP	3.78	-0.81*	2.52	-0.37	3.77	-0.80*	9.13***	-4.17***										
	(1.07)	(-1.80)	(0.68)	(-0.80)	(1.05)	(-1.78)	(6.69)	(-4.14)										
gENER-INT	0.28	-0.29*	0.18	-0.27	0.26	-0.28*	0.27	-0.21	0.23	-0.15	0.27	-0.23	0.27	-0.23	0.23	-0.11	0.29	-0.23
	(1.27)	(-1.75)	(0.56)	(-1.60)	(1.18)	(-1.69)	(1.41)	(-1.34)	(1.21)	(-0.91)	(1.45)	(-1.59)	(1.46)	(-1.60)	(1.35)	(-0.75)	(1.52)	(-1.59)
gCARB-INT	0.07	-0.14*	0.03	-0.16*	0.06	-0.14*	0.06	-0.17*	0.03	-0.11	0.06	-0.19**	0.06	-0.20**	0.04	-0.12	0.70	-0.19**
	(0.39)	(-1.14)	(-0.14)	(-1.78)	(0.30)	(-1.76)	(0.28)	(-1.84)	(0.11)	(-1.36)	(0.30)	(-2.15)	(0.29)	(-2.17)	(0.27)	(-1.23)	(0.42)	(-2.14)
gVA-AGR			0.20	0.09														
			(0.30)	(0.89)														
gVA-IND			0.08	-0.21**														
			(0.21)	(-1.98)														
gVA-SERV			0.03	-0.28*														
			(-0.23)	(-1.79)														
Openness 1					-0.01	0.001												
					(-0.12)	(1.00)												
Openness 2							0.10**	-0.13***	0.08*	-0.12***	0.10***	-0.12***	0.10***	-0.12***	0.13***	-0.17***	0.11***	-0.11***
							(2.21)	(-5.52)	(1.84)	(-5.47)	(2.48)	(-4.67)	(2.47)	(-4.71)	(3.36)	(-5.20)	(2.78)	(-4.60)
gURB-POP									0.05***	-0.03***								
									(6.21)	(-3.88)								
gPOP-y											-2.80***	1.06	2.81***	1.06	-2.92***	1.40	-2.78***	1.03
											(-2.56)	(1.09)	(-2.57)	(1.09)	(-2.58)	(1.36)	(-2.51)	(1.05)
gPOP-a											13.01***	-4.69***	13.03***	-4.66***	10.67***	-3.91***	12.82***	-4.79***
											(6.88)	(-3.21)	(6.87)	(-3.19)	(5.34)	(-3.20)	(6.75)	(-3.28)
gPOP-r											0.25	-0.70	0.25	-0.74	-0.77	0.27	0.54	-0.61
											(0.11)	(-1.21)	(0.10)	(-1.27)	(-0.58)	(0.35)	(0.35)	(-0.99)
gOIL													0.01	0.02				
													(0.20)	(0.37)				
Protocol1															0.14**	-0.12***		
															(2.50)	(-3.10)		
Consciousness																	-0.01*	-0.003
																	(-1.62)	(-1.03)
Observations/Groups	901/83		795/77		890/82		865/79		854/78		854/78		854/78		854/78		854/78	
Number of episodes	76-26		69-19		75-26		71-23		70-23		70-23		70-23		70-23		70-23	
Log-likelihod	-726.97		-622.21		-718.72		-644.93		-645.54		-611.31		-611.21		-582.70		-609.64	
Pseudo-R^2	2.02		1.92		2.16		7.85		6.78		11.72		11.74		13.56		11.96	

See the notes to Table 13.1.