Reason and Unreason in the EU‘s Consumption of Electricity

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Stuttgart, April 2020

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A comparison of Europeans' concern for climate change and their actual electricity consumption reveals a blatant misfit such that the European Union runs the risk of missing its climate goals. To be able to take up effective measures in this regard more insight is apparently required in kind and degree of factors that explain this dissonant behavior. For this purpose a structural equation model is built in the context of global warming around air-conditioners because of the threatening prospect of entering a vicious spiral of cooling rooms, therewith heating up the globe, thereupon cooling more, etc. The model builds conceptually on the distinction between an events material and its ideal dimension: each material manifestation of an event, e.g. the release of a new air-conditioner model or the occurence of a drought carries with it a semantic signal, e.g. for efficient space cooling or for changing climate. While material factors always have immediate and unambigous effects, ideal factors usually need institutionalized mediators like science, politics, or the media what may produce different, even contradicting effects.

The loadings of the model suggest that with respect to weather, the material dimension prevails mediated by income; with respect to air-conditioners, the ideal dimension prevails in form of prices. Taken together, in order to combat climate change, measures would be recommendable that put a climate price on electricity and at the same time relief people from the burden of income to create space for the burden of climate action.

Europe‘s Weather and its concern for Climate Change

Concern for climate change has risen in the European Union since 1990 both on the civil and on the political level. The EU member states have committed that, compared to 1990, by 2020 they will have decreased greenhouse gas emissions by 20% and they will have increased the current produced by renewables to 20% alike. Finally energy consumption shall in the same period drop by the very same 20%.

The EU politics is supported by its citizens. More than half of Europe's population now considers climate change to be a very important political matter (*fig. 10*). This means for all member states but the Netherlands a large increase of concern with largest increases in Portugal and Italy (EC 2019).

The concern seems to be in line with manifestations of climate change in Europe. Temperatures beyond comfort, so-called cooling degree days, have risen continually all over Europe (*fig. 9*); the number of days with extreme heat and heat stress has more than tripled since 1950 (Lorenz, Stalhandske & Fischer 2019). Since 2011 climate change has increased in 14 member states – but also decreased in 13 member states. Largest increases can be seen in Scandinavia while Latvia shows the largest decreases (EC 2019). On a larger scale, however, with respect to the rise of temperature in the member states' capitols, Latvia ranges between Sweden and Denmark with a rise of 1,1°C since 1979. Sweden together with Ireland reports the least cooling degree days whereas Malta and Greece report the most (*fig. 11*).

The Europeans‘ concern for climate change is independent of outside temperature. Between cooling degree days and concern there is no significant relation (r=0.18). On the member state level the concern for climate change is on average the same for the first 25% states with the most cooling degree days and for the first 25% states with the least cooling degree days (*fig. 12*). Neither is the concern affected by the occurrence of climate conferences nor cultural events like blockbuster movies dealing with climatic catastrophes (Capstick et al. 2015).

Likewise are the statements on the political importance of climate change independent of people's climate action. Although many Europeans state to have taken themselves measures against climate change there energy consumption in Europe has not dropped since 1990 but even risen by 0,4%. The rise is due to the energy consumption in the transport sector and the service sector, whereas industry strongly reduced its consumption. Households, in turn, increased their consumption. Main driver here is the consumption of electricity with a yearly average growth of 1,0% to a 32,7% in 2018 (*fig. 13)*.

Household appliances and lights are consuming meanwhile far less electricity, and while TV and electrics show a more or less constant consumption, there has been a more than fourfold increase of electricity consumption by air conditioners (*fig. 16*) which nevertheless still have a low share of 0,5% in European households' electricity consumption. In total, however, greenhouse gas emissions from space cooling have tripled since 1990 (IEA 2018).

Again, even more surprisingly, there is no significant relation between cooling degree days and energy consumption without heating. The seven member states with the most cooling degree days do not differ in their average energy consumption without heating from the seven states with the least number of cooling degree days. At least cooling degree days and electricity consumption of air-conditioners are somehow positively correlated (r=0.50).

By way of transitive inference people's energy consumption without heating should be, and indeed is, uncorrelated to their statements on the importance of climate change (r=-0.09). Regressing household's energy consumer types (space warming, warm water, cooking, and appliances) and tokens (space cooling, light, fridge, freezer, washing machine, dishwasher, TV and dryer) on household's energy consumption does not reveal any factor with a potential explanation of the consumption's variance.

The incongruence between stated concern and performed action seems confusing. Europeans do accept personal responsibility for climate change (correlation between statements on the importance of climate change and on personal responsibility is high: r=0.83), and they do stress the importance of personal action (62,6%), however when it comes to personal action, the correlations go down: r=-0.02 between energy consumption and the commitment to personal action.

This confusion might be resolved by the elucidation of what Europeans understand by personal climate action: namely to reduce and separate waste (80%), to reduce disposables (58%), to buy energy efficient gadgets (55%), to use alternatives to private car (38%), to insulate houses (26%), to install smart meters (20%) or to switch to renewables (15%). However this does not explain what finally makes people consume more energy than their attitude to global warming rationally allows. Given the EU polls' statements regarding the importance of climate change, it must be pretty strong motifs or causes.

Identification of Factors determining Energy Consumption

Previous research has identified several factors predicting energy consumption. These belong to climatic, energetic, journalistic, political, economical and scientific fields. A short look at each of them may be in order.

First of all, there is the factor climate itself (Carelton & Hsiang 2016), regularly operationalized as weather (Auffhammer, Hsiang, Schlenker & Sobel 2013). Among the climatic factors temperature stands out: climate change is strongly related to temperature anomalies which not only affect public perception of climate change (Capstick et al. 2015) but also directly raise energy consumption considerably, especially in order to cool spaces (BP 2019) – although on a minor dimension in Europe (Auffhammer & Mansur 2014). Together with temperature humidity shapes cooling degree days (IEA 2018). Like energy consumption and the concern for climate change all climatic factors (temperature, humidity, sea level, floods, storms, hails and lightning show a rising slope (*fig.s 1, 2 and 3*).

The same holds for the cost of electricity (IEA 2018) where prizes have arisen in spite of the growing share of renewable energies in power production (*fig. 4*).

With respect to the journalistic factors we see trends in opposite directions: while media attention to and coverage of climate change has risen to a higher level recently, the subscribers and readers of daily newspapers are constantly declining (*fig. 17)*, lessening the media effect on public concern for climate change (Capstick et al. 2015).

A measurable effect on public concern for climate change is established for political factors, too (Capstick et al. 2015). And there is indeed a significant correlation r=0,79 (p < 0,01) between green parties' results at national and European parliamentary elections and the statement of climate change's political importance in the poll. While all political parties' general preoccupation with climate change fluctuates, ecological parties are on the rise all over Europe against a declining electoriate turnout (*fig. 5*).

Economical factors comprise the gross domestic product (IEA 2018), income, unemployment rate (Capstick et al. 2015) and the air conditioner market. The former show a clear upward trend with strong fluctuations in unemployment; the latter are characterized by price and efficiency of air conditioners (Sha, Phadke & Waide 2013). Both sale and stock of air conditioners in Europe increases in line with the electricity consumption for space cooling (*fig. 8*). The air conditioner market in Europe is relatively small (BSRIA 2019) but growing rapidly (CLASP 2011), and it is mainly dominated by the service area (Pezzutto et al. 2017); should residentials equally gain access to air conditioners 45% of European households‘ electricity consumption would be consumed by air-conditioners (Delmastro & Dulac 2019), taking into account that air-conditioning impacts electricity consumption more than previously believed (Davis & Gertler 2016).

Finally, population growth and its concentration in urban areas are considered imminent factors (IAEA 2018). Buildings absorb and store heat and the consequential running of air-conditioners heats cities further up driving cooling demand so far as to intensify the use of air-conditioners or to buy even more of them. For elder people cooling may become a question of life and death because they are less heat tolerant than the younger ones. And people in Europe grow older as population and urbanization grow and the death rate declines (*fig. 6*).

We add the factor science because of its testifying function, highlighted by the climate gate in 2009 (Capstick et al. 2015), and register the steep growth of public spendings for climate research and the number of therewith published articles on climatic affairs (*fig. 18*).

Theoretical Context and methodological Approach

The peculiarities of the mentioned factors leave us with the dilemma of either regulating room temperature or world temperature. The current situation which requires climatically a reduction of energy consumption is the very same situation which makes us consume no less energy. Residential electricity consumption thrives against strong convictions regarding climate change, against more efficient and less power consuming household appliances, and against rising electricity prices.

When we then ask for the causes of this counterintuitive behavior, i.e. our electricity consumption we refer conceptually to a stimulus-response model of human behavior. Omitting here the psychic treatment of stimuli in detail, the organism is put as a kind of black box between perceived causes and an individual's reaction to them (Skinner 1974). The intermediate of the organism leaves room to discern between statements and actions, between declared and revealed preferences (Samuelson 1938). What is more, we may introduce material and ideal stimuli (*fig. 23*) to satisfy the ambiguous role of climate in determining our behavior.

Like the organism is, on the individual level, a supposed mediator between stimulus and response, we suppose climate to be mediated by institutions on the socioeconomic level. That is, while heat, rain and storm materially affect people, mediators like science, the media or politics deliver the ideal content of climate change to the agent. The differentiation between a material and an ideal aspect of a common cause corresponds to the differentiation between a direct effects of climate and a belief effects of climate (Hsiang 2016). Regardless of the actual weather people shape their behavior in accord with their beliefs about future climate manifestations: An agent's belief in continuous local warming causes her to purchase an air-conditioner (belief effect) which reduces the chances that she will suffer from heat on cooling degree days (direct effect).

The ideal aspect of a stimulus is linked theoretically to semantic memory in decision-making, whereas the material aspect contributes to episodic memory (Tulving 1984); sensu stricto, ideally caused behavior results from knowledge-based decisions (Missier et al. 2014) and allows for both the widely acknowledged doubt on the existence of any immediate stimulus-based decisions (Alba, Hutchinson & Lynch 1991) and the equally prolific doubt on the concept of a rational, fully informed consumer (Rapson 2014). So, the causal chain originates with a stimulus, is then processed by the organism in a way that we can refer to the components as a material or an ideal factor, and finally the resultant of both leads to consumptive behavior.

Economics captures this difference very well: there you have a product with certain features, some of them concern its practical usage, for example an air-conditioner that cools space; and some of them concern economic purposes with a signaling function, most notably the price, but also the efficiency of a product. These signals are supposed to play a role in determining the decision whether to buy an air-conditioner, and if so to buy which air conditioner. That is why one and the same cause may be treated as an ideal or a material factor (*fig. 21)*.

This approach transferred to a climate scenario means that we can ask whether weather has a stronger influence on energy consumption by way of killing people, interrupting transmission lines, paralyzing markets, and cutting income, or by way of a climate discourse, reasoning on the climatic causes of severe weather events – each of them taken as a warning – bemoaning its victims and probing for measures to manage climate as global commons (Nordhaus 1994). To know whether a factor determines energy consumption as a material factor or as an ideal factor may help shaping these measures effectively.

To sum up: we want to find out which factors determine energy consumption in the EU member states to what degree with a special regard to the air conditioner market and to the material and ideal dimension of factors, whereby a material factor is conceived to contribute perceptively (it makes us feel, e.g. comfortable) to the episodic memory in decision-making, and an ideal factor is conceived to contribute reflectively (it makes us think, e.g. compare, calculate etc.) to the semantic memory in decision-making.

The outlined scheme precludes the common methodological approach of using utility functions because this meant overlooking the immediate effect of the function's inherent factors. Therefore, this study on people's adaption to climate change is upstream to research on adaptations on intensive or extensive margins. In view of the lack of an exhaustive list of factors that fully describe all socioeconomically relevant parameters (Hsiang 2016), we may, without loss of generality, confine ourselves to measures of intensive margins, that is measuring how energy consumption changes with climate change (Auffhammer & Mansur 2014). Instead the scheme requires a comprehensive approach that covers the overall effects of the factors, i.e. the extent to which the adaptations interact with direct effects of climate (Hsiang 2016).

This will be undertaken in a timeseries analysis of the factors for the EU 28 from 1990 to 2018, not in a cross-sectional analysis because the most comparable group for a certain population is itself (Carelton & Hsiang 2016); and it will be undertaken in a top-down approach with a linear model based on macroscale economics (gross domestic product, income, prices etc.) and with climate taken as given by climatologists (*fig. 24*), but without nonlinearities (Hsiang 2016) and bidirectional feedback loops between economics and climate (Pretis 2020), and without considering the details of the member states' behavior within the European Union (Kang & Spanos 2014).

Putting the Factors together: The Model and its Data

Exploratively 59 indicators for the above mentioned factors (*fig. 29)* have been collected for the years 1990 to 2018 (N = 29) from different sources, official and academical, with 322 missing values (18,8%). From these 21 factors seemed promising enough to inform the 14 factors constituting the model for energy consumption in the European Union. The indicators for severe weather events are aggregated to one because all of them equally represent climate change, making a regress to the single event uninformative and futile, and leaving us with a total of 17 indicators. In the final sample we then find 82 missing values (16,6%) of which urbanization alone claims 23. All missing values were imputed numerically by trend or co-trend analysis.

The model assumes that severe weather events affect residential electricity consumption indirectly over its effects on population, economy, politics, and the media. Politics and the media in turn affect residential electricity consumption mediated by trust in politicians and the reception of media. As a proxy for trust in politicians we propose electorial turnouts, and for climate politics we propose ecological parties' results at national and European elections. The model assumes no measurable direct effect of severe weather events because natural catastrophes mainly affect industry and energy generation (Tol 2002), whereas residential electricity consumption is mainly affected by temperature (Ebinger & Vergara 2011). Temperature is often subsumed under the category of weather, but here it is used separately with cooling degree days as its indicator.

While we take media to be driven by up-to-date weather events, this should not be the case with research which is supposed to be directed rather by trustworthy theories than by newsworty happenings. However, the knowledge produced by science informs the public discourse via politics and the media, both of which absorb and multiply it. Apart from weather and temperature, knowledge about climate change is therefore treated as an exogenous factor on par with market prices (for electricity and air-conditioners) and the share of renewables in energy supply. Finally, electricity consumption also has a signaling function in the climate discourse when reported in the media and thus enters a feedback loop on itself via media reception.

Altogether we suggest a structural equation model (*fig. 28*) with 22 latent variables, 6 exogenous and 16 endogenous. The 16 endogenous variables result from 8 factors and its 8 disturbances for the endogeneous factors‘ residual variances that is not explained within the model. Together they form 12 paths from exogenous variables to electricity consumption. These paths and 141 parameters shall be estimated by k = 17 indicators which equally provide 153 known values (k variances and $\binom{k}{2}$ covariances), whereby the model is justly identified.

This just identification is achieved through fixing the error variances of single-indicators without measurement error to zero, and those of single-indicators with measurement error to external reliabilities (Williams & Hazer 1986). All factors have indicators with uncorrelated error variances, and for each indicator there is an indicator with at least one uncorrelated error variance. Thus, the model is well specified, too. It might be however under powered. Usually samples with $N > 200$ are required to test a structural equation model. Exceptions are allowed for smaller sample sizes with respect to models containing many factors that correlate strongly and that are loaded by single indicators in the main (Kenny 1979). Both is provided by the dataset with an average correlation of $r = |0.77|$ (*fig. 20*) and 10 factors with single-indicators out of 14 factors.

The correlation matrix visualizes, too, that the factors of the climate cluster (cooling degree days and severe weather events) correlate but with themselves what suggests independence of the factors and promises sound results in its test which is applicable because the variables follow a multi-normal distribution (Mardia $p > 0.1$). Remarkable is furthermore, that only media coverage and the green parties' election results correlate significantly with the consumption of electricity in households. This suggests that the main effects of the factors are indirect effects which could be revealed by SEM.

Putting the Model to a preliminary Test

The test returns a comparative fit index (CFI) of 0.91, a root mean square error of approximation (RMSEA) of 0.00 and the standardized root mean square residual (SRMR) of 0.07 without any p-value because the χ^2-test breaks down at zero degrees of freedom. Ceteris paribus this indicates a moderate fit. For a better understanding we present the results in effect sizes calculated as the estimated loadings divided by their standard deviation. In this notation the total effect of all factors on energy consumption is $d=1.61$ which looks pretty strong – and looked even stronger if we applied more recent effect size measures (Gomer, Jiang & Yuan 2019), e.g. $\varepsilon_3=2.07$. However, the $\beta=0.9$ confidence interval is immensely large, ranging from -496 to 500.

Again, there is no α-level because a central χ^2-distribution with zero degrees of freedom is effectively zero (Siegel 1979) with no cumulative density function. For this reason the critical value must be calculated from the second order error probability (1-ß) what can be done because for non-central χ^2-distributions, there exist normal approximations (Sankaran 1959). The required noncentrality parameter can be derived from the discrepancy function of the observed and the modeled covariance matrix. Setting ß=0.9 leads to a critical value of 92.6 (*fig. 26)* which is far from

1.61 but easily covered by its confidence interval. In the end, even effect sizes, only allow here for a relative interpretation of the test.

In the relative setting temperature has the strongest effect: the higher the temperature the more electricity is consumed, presumably for cooling. Second comes the air-conditioner that drives electricity consumption with low prices (coded invertedly) and low efficiency (negative loading) which is a combination of extensive and intensive margins: if air-conditioners are cheap people buy more of them (extensive), and when used, the inefficient air conditioners consume more energy (intensive). Also, consumption rises when electricity prices rise. This manifests the high price inelasticity for electricity, here mean $\Delta = -0.01$, in Europe (Cserklyei 2020), but it also suggests that the demand for air-conditioners is predominantly guided by prices and therewith confirms the asymmetry between electricity price and energy efficiency where one would expect a symmetry: high electricity prices should go together with highly efficient air-conditioners (Rapson 2014).

The share of renewables in energy production equally contributes to electricity consumption. This indicates a climactic rebound effect (Mizobuchi & Takeuchi 2019) in the sense that the less detrimental for the climate the available energy appears to be, the more one feels free to consume of it, a misapprehension in size (Camilleri et al. 2019) that leads to even more detrimental consumption than with a lower share of renewables. Thus, sustainable energy production seems to signal the wrong message with respect to climate protection.

Scientific papers bear the right message but with a rather small effect: to some degree less energy is consumed the more papers are published. This suggests that neither media nor politics succeed in transporting the message of science effectively to society, especially when one considers that the ideal effect of severe weather events is even smaller though on a positive scale. Journalistic articles load very little on their perception, that is, most of them are simply ignored and don't reach the mind of the reader, whereas politicians bring climate change heavily to the ballot box – where it remains mainly a programmatic agenda that only rarely become acta.

On the material side, severe weather events have a stronger influence in the opposite direction: the more heavy rain, storms, floods and hail the less energy is consumed. This indirect effect is mediated three times stronger through economy than through population which also loads negatively on economy. Economy's negative effect results from its income effect: the higher the income, the lesser electricity consumption. These numbers are consistent with the finding that concern for climate change rises with income (Shum 2012). Its explanation assumes that people's concern is limited such that it can increase on one matter only in so far as it decreases on another: when concern for income is reduced, concern for climate change can augment, or actively, when enough money is earned, people care for the right money to earn (Capstick et al. 2015).

In case of severe weather events, they are more effective as material factor than as ideal factor. In sum , however, ideal factors are more effective than material factors (*fig. 23)*. This is due to the matter that there are more exogenous ideal factors built in the model than exogenous material factors. On average the effect size of material factors is 1.03, and that of ideal factors 0.84 with no reason to reject the null hypothesis that both are of equal size ($p > 0.9$).

Broadly speaking, one could summarize the results by saying that people base their decisions with respect to climate action mainly on market signals: up to a certain income they buy cheap but inefficient air-conditioners, grossly underestimating its electricity consumption, because they neither read newspapers nor engage in politics, but trust in a technological adaption to climate change like power generation from renewables, instead of adapting themselves by changing their energy consumptive behavior; anyhow the market is much stronger affected by climate change than is individual climate action. Only by detour over market resonances people's behavior changes.

In this sense, the model brings forward plausible implications, and is robust in its results against choices of reliabilities as error variances in the model specification. However, the results are highly sensitive to changes in variables. Replacing urbanization by age, for example, changes the results dramatically, not so much in the fit-indices but in the effect sizes - even changes in sign may occur. This calls for the outmost caution when using the model as evidence for a causal relation. Ever since it goes the other way round: causal relations supply evidence for the external validity of the model. My impression is, that the structural equation model testifies a causal relationship not before it is established otherwise.

Apart from that, the presented model suffers internally from its missing values; the imputation creates potential biases in the estimated coefficients and standard errors what may be fatal as the correlation between weather variables varies in sign and magnitude across regions (Auffhammer, Hsiang, Schlenker & Sobel 2013). Furthermore, the model does not take into account the tremendous heterogeneity in weather, electricity prices and incomes of the member states separately (Auffhammer & Mansur 2014). In any case, more detailed research would be necessary to support the model implications.

One reason to bring the case to a structural equation modeling trial was that ordinary linear regression did not yield much insight into the interdependency of weather and energy consumption. Of the exogenous factors only electricity price stood out as significant contributor to the explanation of the variance of electricity consumption. A principal component analysis shows singular loadings of the first four eigenvectors on research publications, cooling degree days, price of air-conditioners, and electricity consumption respectively; factors with the strongest loadings on the first three components are prizes for air-conditioners and electricity, however their scree plot sugggests (*fig. 25*) a model with a single variable only.

To make sure that the model does not fail because of lack of immediate causation but stands against effects mediated by time, a covariance analysis is conducted with a two years lag. The Johanson-test suggests with a significance level of $\alpha = 0.01$ that timeseries of five factors can provide stationarity in their residuals. This can be achieved (*fig. 18*) to the significance level of $\alpha < 0.05$ with seven factor combinations of which six combinations contain electricity consumption. For the combination with the smallest p-value the long run relationship between electricity consumption and its determining factors would here take the form of

$$elcons = 0.64 \cdot pub - 0.29 \cdot coold - 1.67 \cdot acprice + 0.33 \cdot elprice \quad .$$

Note the absence of severe weather events – they don't form part of any of the combinations with stationarity. Only temperature (cooling degree days) remains in the equation with strong market signals (prices) and scientific productivity. Although the signs point in opposite directions, this, apart from the hard task of giving a meaningful interpretation, confirms the model's emphasis on economic factors rather than on climatic factors generally, and on the ideal dimension particularly: Concerning electricity consumption we think in terms of prices, if we think at all, not in terms of climate change. Thus, also in the long run perspective, episodic memory is at work, the memory of unbearable heat, not the semantic memory, the memory of heat as af warning sign of global warming.

Conclusions on the main Drivers for cooling Demand

Global warming affects electricity consumption only as material factor: rising temperatures fuel consumption while severe weather events throttle it. Knowledge about climate change as an ideal factor is harmlessly ineffective; all other ideal factors increase electricity consumption, even the only non-market related factor of sustainable energy production. This rather depressive conclusion sheds doubt on the rationality, or at least the reasonableness of consumers' behavior. At least, containment of climate change seems to be perceived possible only by way of technological adaption, not by behavioral adaption. The pace of technological progress is even considered the ultimate hope (Davis & Gertler 2016).

With respect to air-conditioners the adaption is technologically characterized by their efficiency. More efficient air-conditioners shall reduce the growth of electricity consumption by half (IEA 2018). This is, by its own standards, very optimistic, to say the least. It not only disregards the low efficiency elasticity of the electricity demand on the air conditioner market (Mizobuchi & Takeuchi 2019) but it would also outperforms the average gain off efficiency of other household appliances, which is roundabout 20% since 1990.

But even in this optimistic scenario a conservative estimate for the share of air-conditioners in European households from the current stock in residentials (IEA 2018) is 19,4%. Supposed an equal distribution of air-conditioners with other household appliances, which is about 90%, this meant an additional consumption of 26,6 TWh, more than doubling the share of space cooling in residentials electricity consumption to 5,8% and raising overall consumption by 3,3%. This would account for a total increase of electricity consumption by 37,1% since 1990, a plus of 13,4%.

Without additional air-conditioners residential electricity consumption already increased by 32,7% in the EU since 1990 which means an average yearly growth rate of 1,0%. Meanwhile 39,8 more cooling degree days (+77,0%) are reported from the member states, and the average temperature has risen by 0,3 °C which implies annually 9,0% more electricity consumption per degree centigrade, comparable to China (Li, Pizer & Wu 2019). For Europe this figure would rise to 23,6% more energy per degree centigrade annually if we relief only on the technological adaption mentioned above. Facing climate change and seeing that the growing pre-valance of air-conditioning does not make hot areas more attractive (Biddle 2010), this does not seem to be the appropriate adaption.

For this reason efficiency standards or rebates for efficient appliances (Auffhammer & Mansur 2014) seem to be measures of minor importance. The same holds for information campaigns (Auffhammer & Mansur 2014): when it comes to climate action, market signals rank higher than climate signals. Not even strong concern induces pro-climate behavior with respect to electricity consumption. The way suggested by the proposed structural equation model is to raise income in order to bring climate action within reach of the people. In a sense, they must first come in the position to afford climate protection.

The main problem here is how to get an economy flourishing while setting an effective CO2-price on electricity, and how to induce people to act in accordance with their concerns. Further research is needed to bridge that gap. To get the right picture of electricity consumption under global warming, therefore, both more detailed and more comprehensive analyses are required that should include data on a regional level and provide a fuller specification of the relevant factors, not only adhering to climatic aspects, in order to lay the path for causal models that also incorporate nonlinear interdependencies (Hsiang 2016). A first step could beat the examination of regions where high temperatures do not generate high levels of air conditioning usage.

Tables and Figures

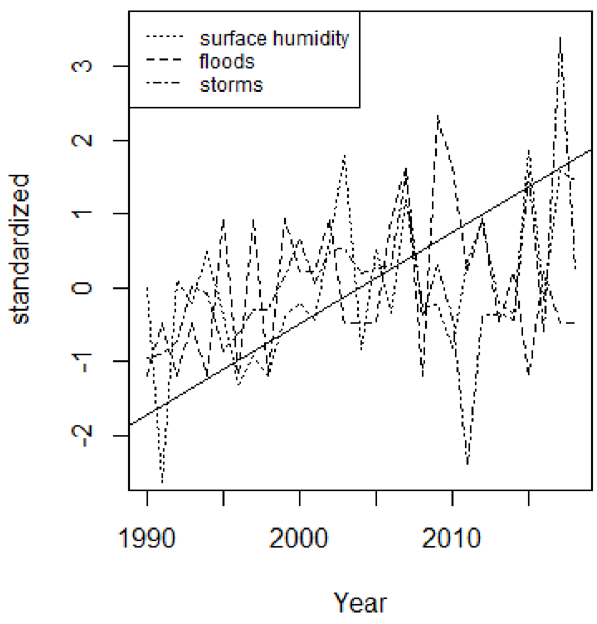

Figure 1: Indicators for climate change (i).

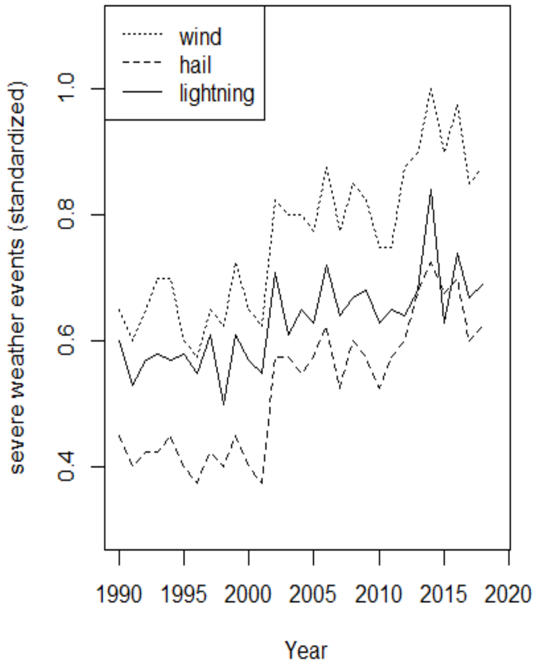

Figure 2: Indicators for climate in Europe (ii).

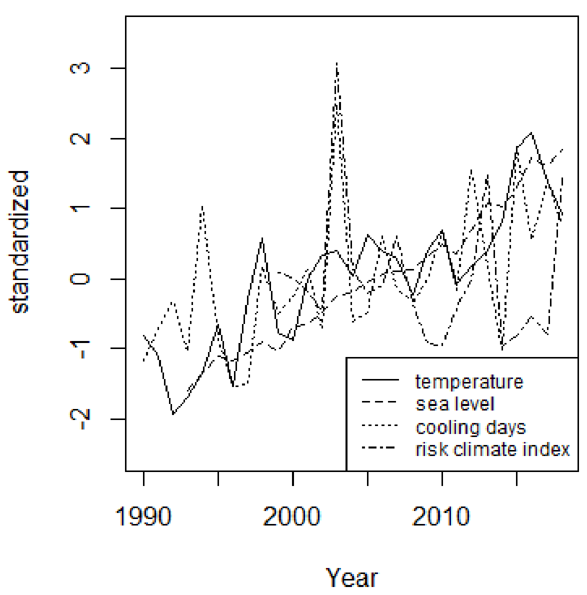

Figure 3: Indicators for climate change (iii).

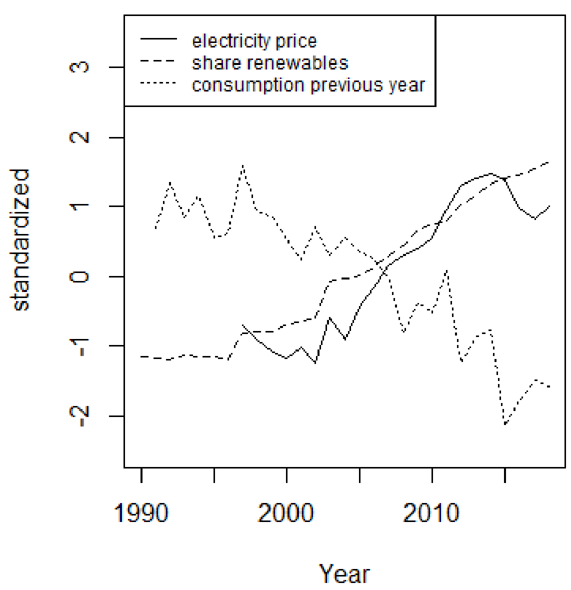

Figure 4: Indicators for the electricity market.

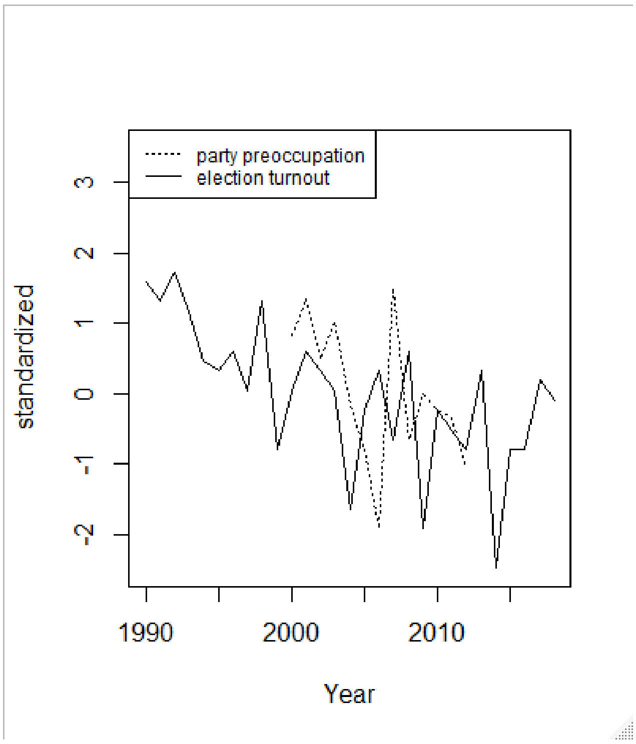

Figure 5: Indicators for climate politics.

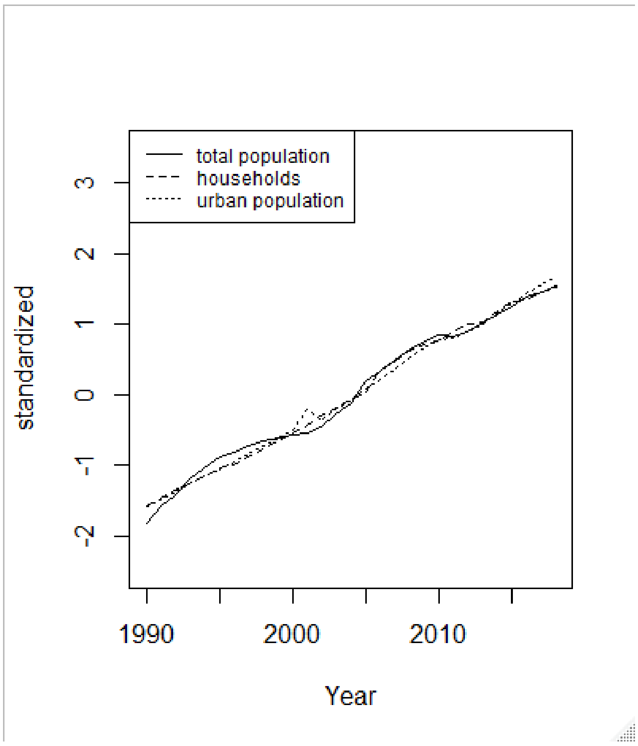

Figure 6: Indicators for population.

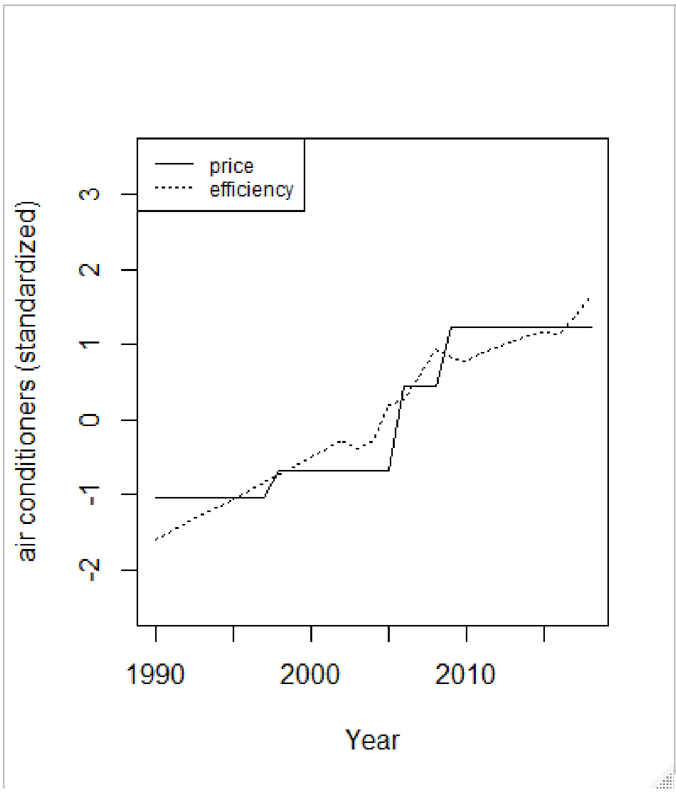

Figure 7: Indicators for air-conditioners as market product.

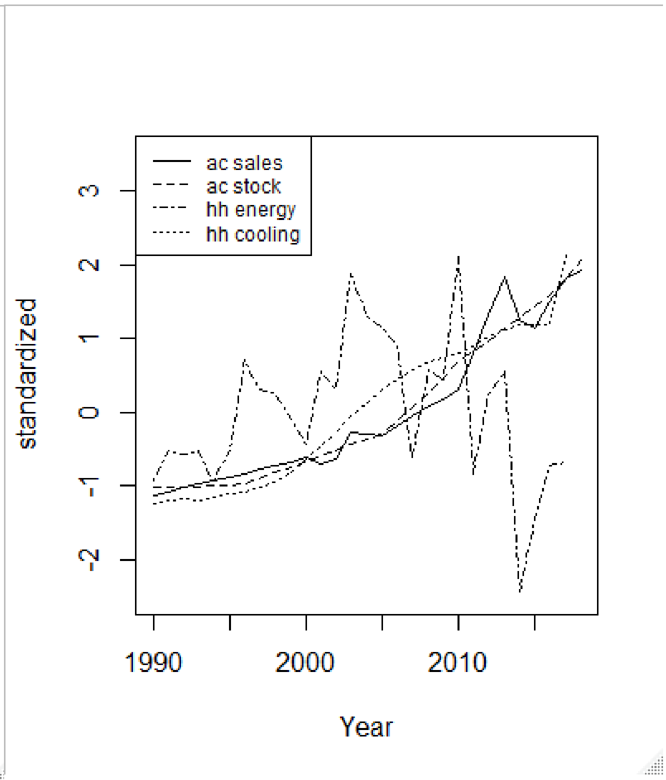

Figure 8 Indicators for energy consumption of air-conditioners.

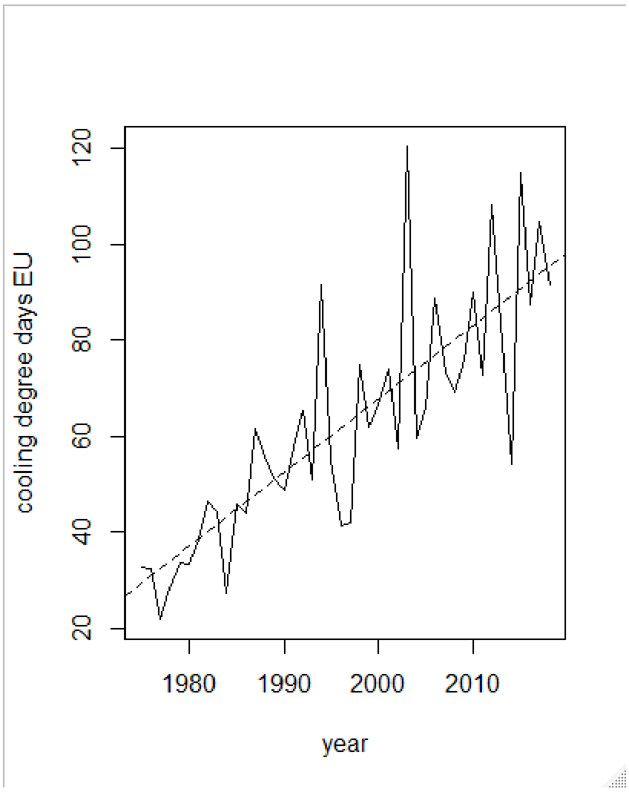

Figure 9: Indicator for rise of temperature.

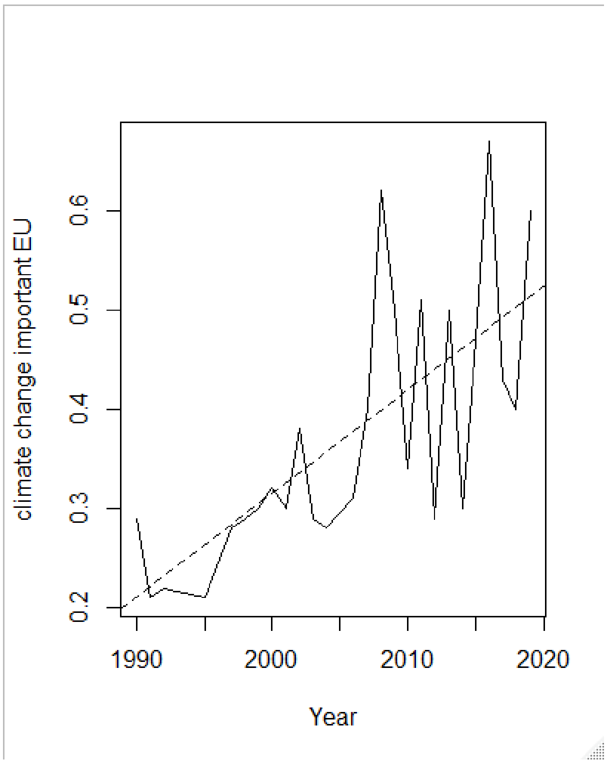

Figure 10: Development of Europeans' concern for climate change according to EU polls..

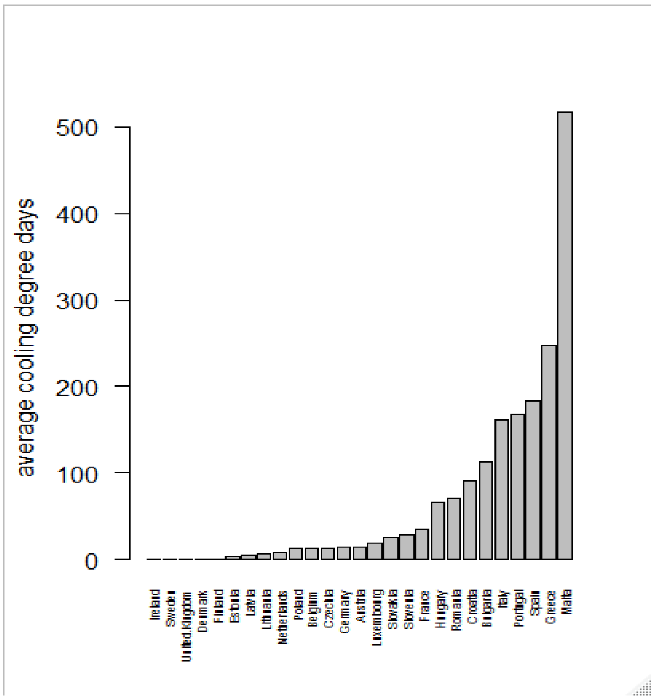

Figure 11: Frequency of cooling degree days in member states.

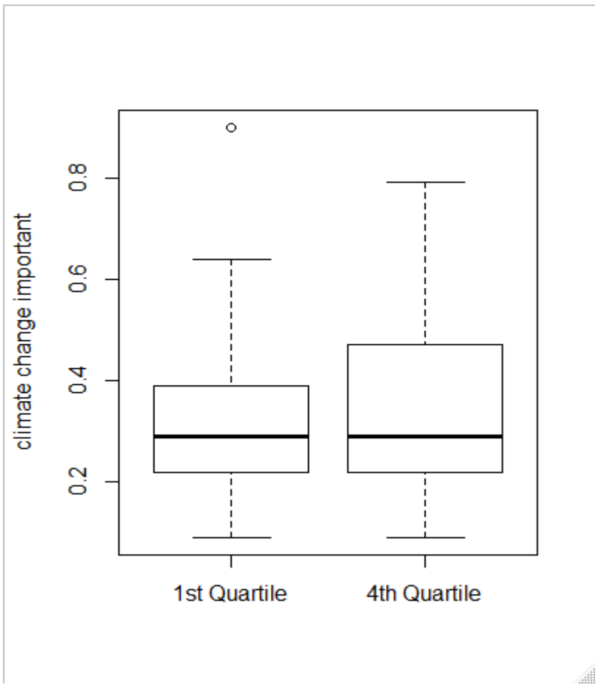

Figure 12: Box plot for member states' concern clustered according to cooling degree days.

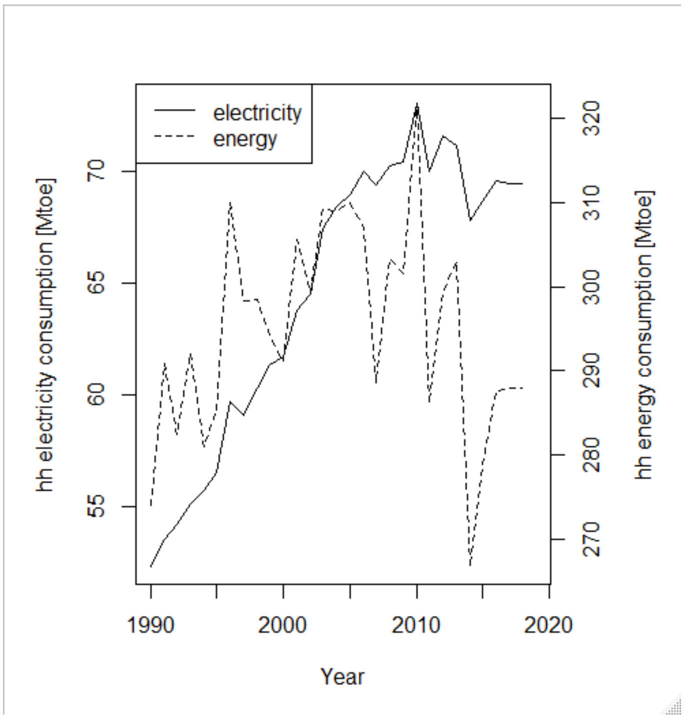

Figure 13: Energy and electricity consumption in Europe.

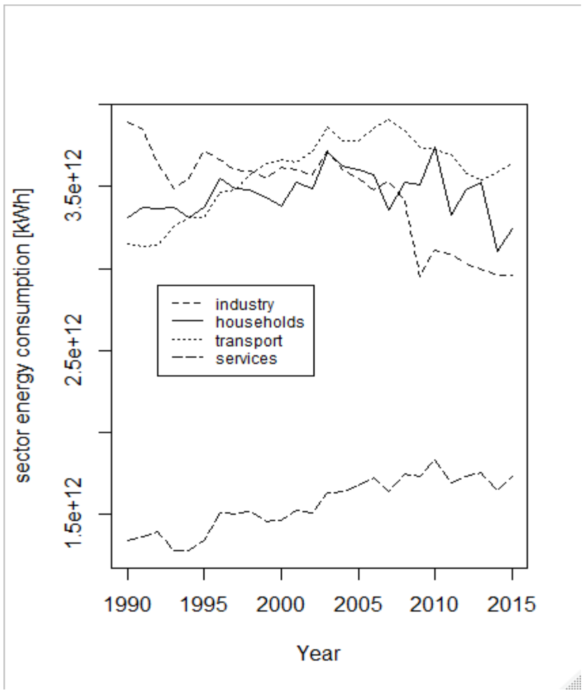

Figure 14: Sectorial energy consumption in Europe.

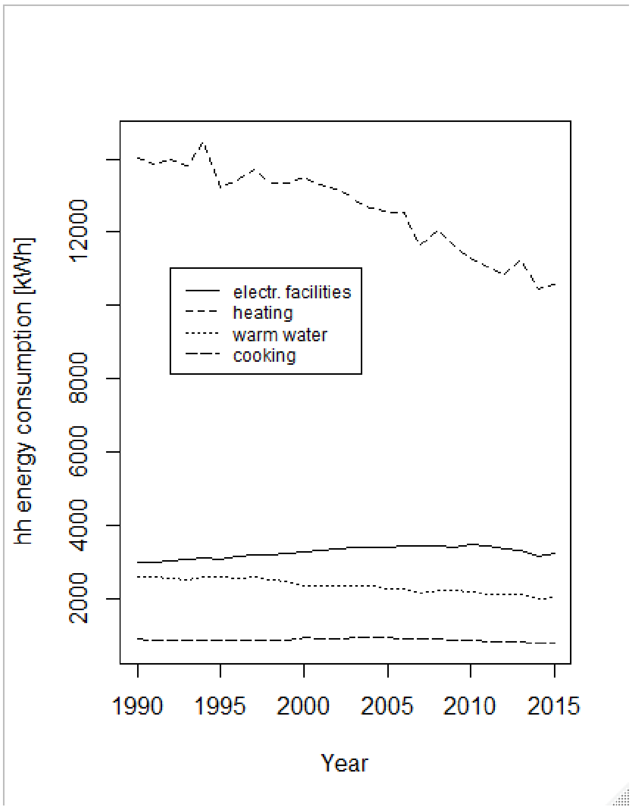

Figure 15: Residential energy consumption per household by purpose.

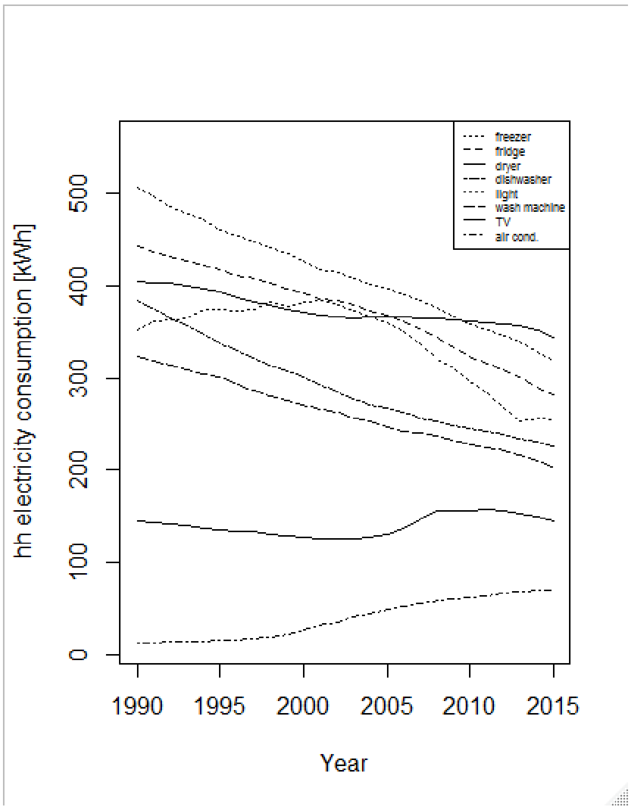

Figure 16: Residential energy consumption per household by appliance.

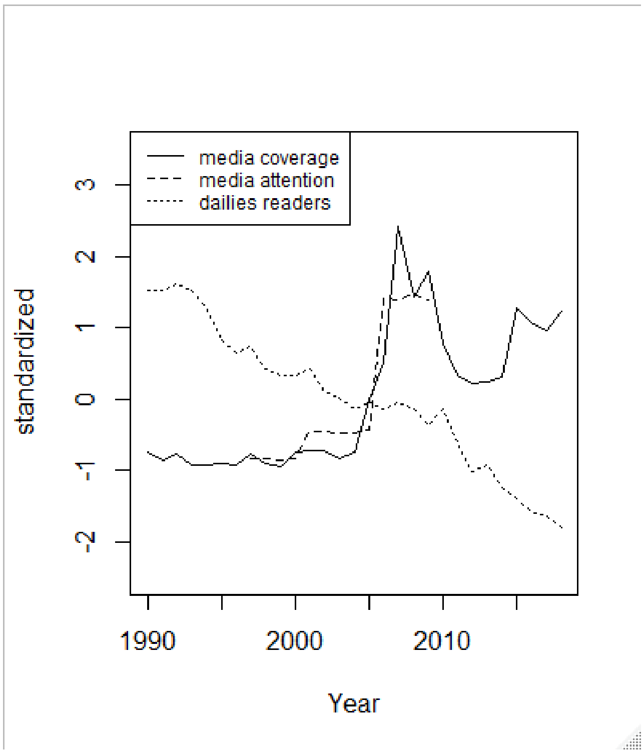

Figure 17: Indicators for climate in the media.

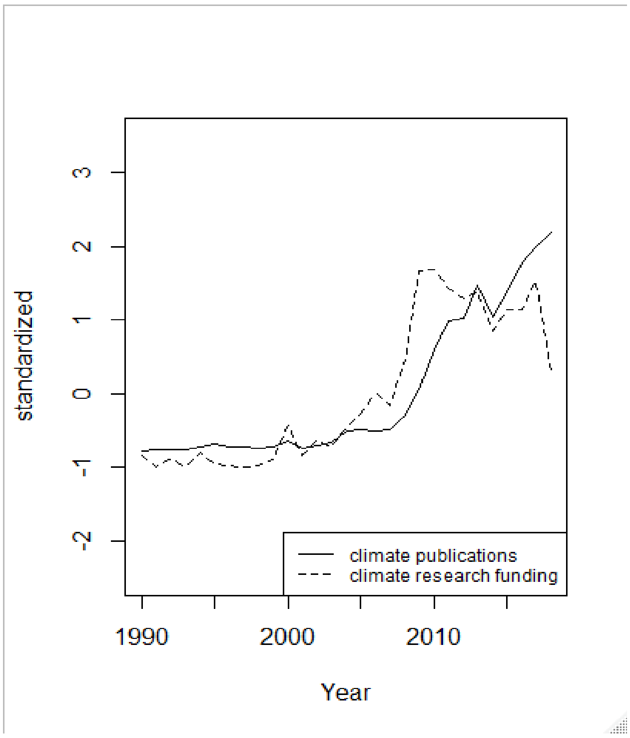

Figure 18: Indicator for climate knowledge.

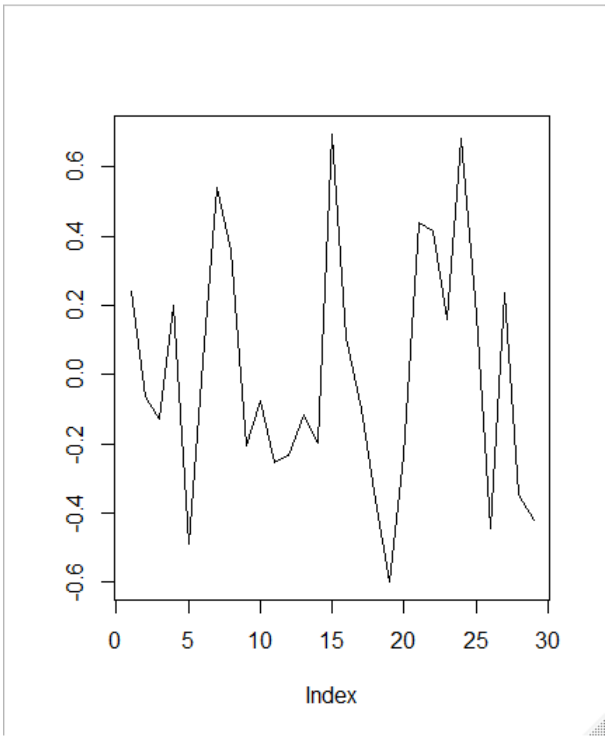

Figure 19: Stationary combination of five factors.

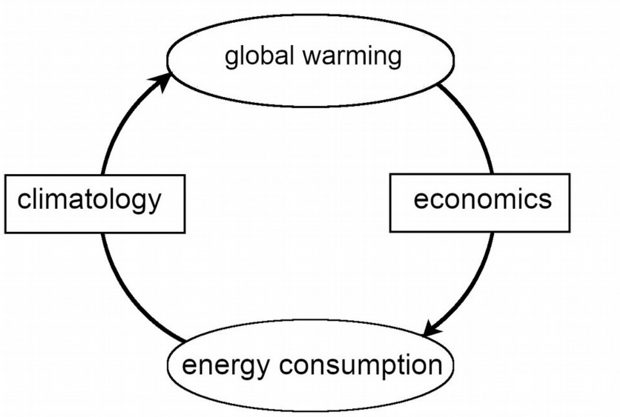

Figure 20: Climatology's and economics' division of labour

category	material factor	ideal factor	
		pro energy	pro climate
climate	droughts storms floods		severe weather events
energy market	electricity	price	share of renewables
	electrics	price efficiency	
society	old people heat deaths work life balance account balance		climate victims

Figure 21: Classification of factors

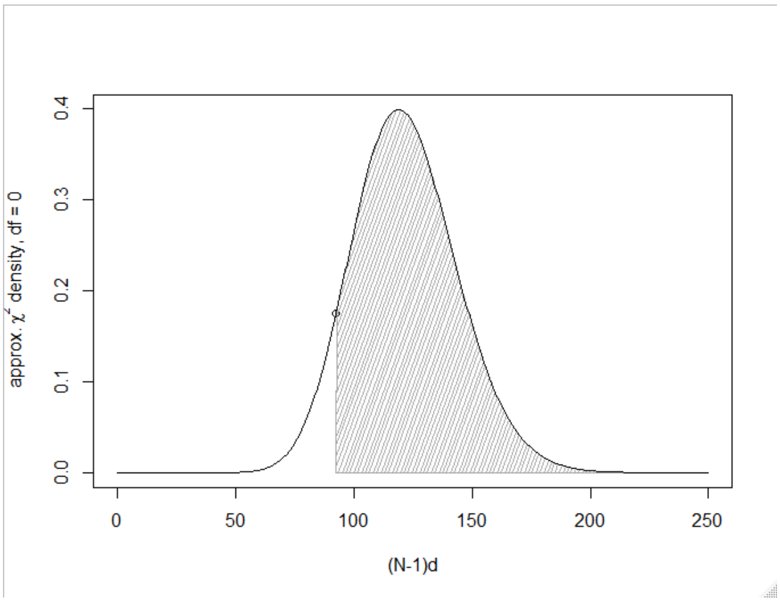

Figure 22: Determining critical value for df = 0.

material factors			ideal factors		
temperature		3,21	product		1,73
weather	economy population	-1,15	electricity		1,27
			sustainability		1.23
			weather	politics media	0,04
			knowledge		-0.09
total		1,62	*total*		2,87

Figure 23: Effect sizes (standardized)

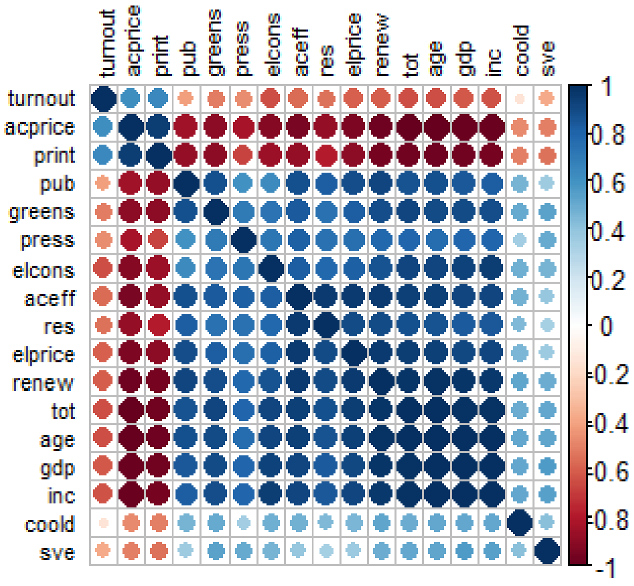

Figure 24: Correlation matrix of indicators.

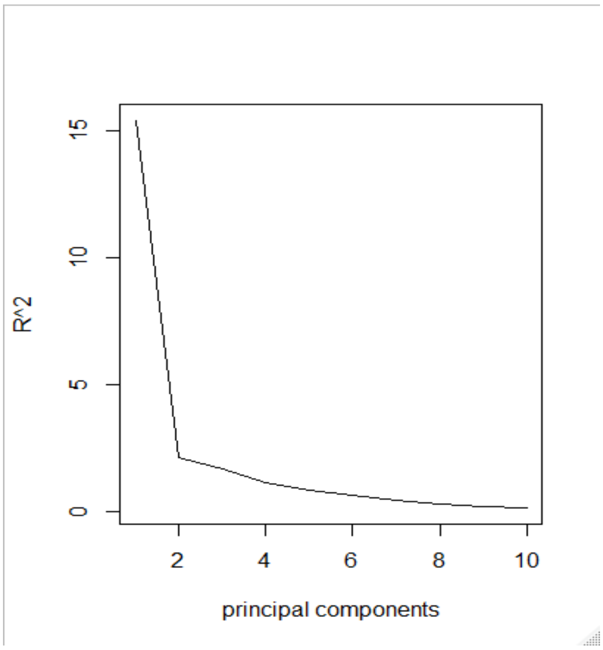

Figure 25: Scree plot of a principle component analysis of the dataset.

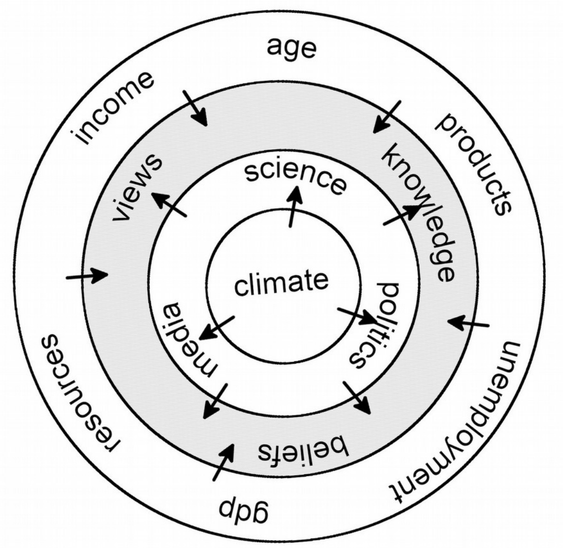

Figure 26: Two-dimensional model of material mediators to the ideal sphere.

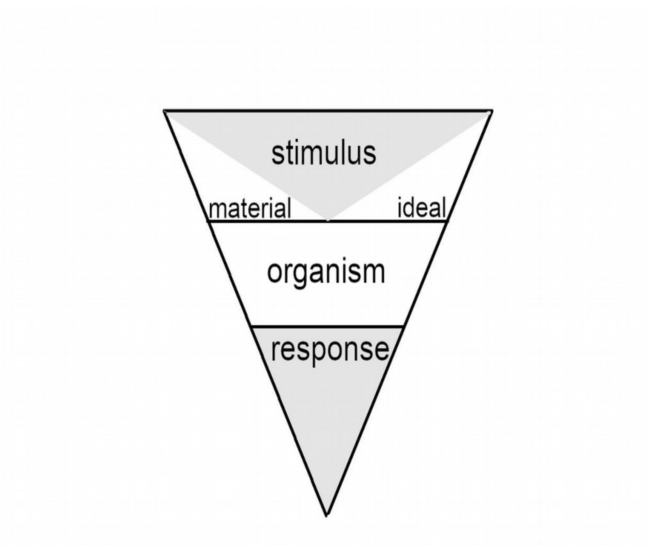

Figure 27: Adapted stimulus-organism-response model of behavior.

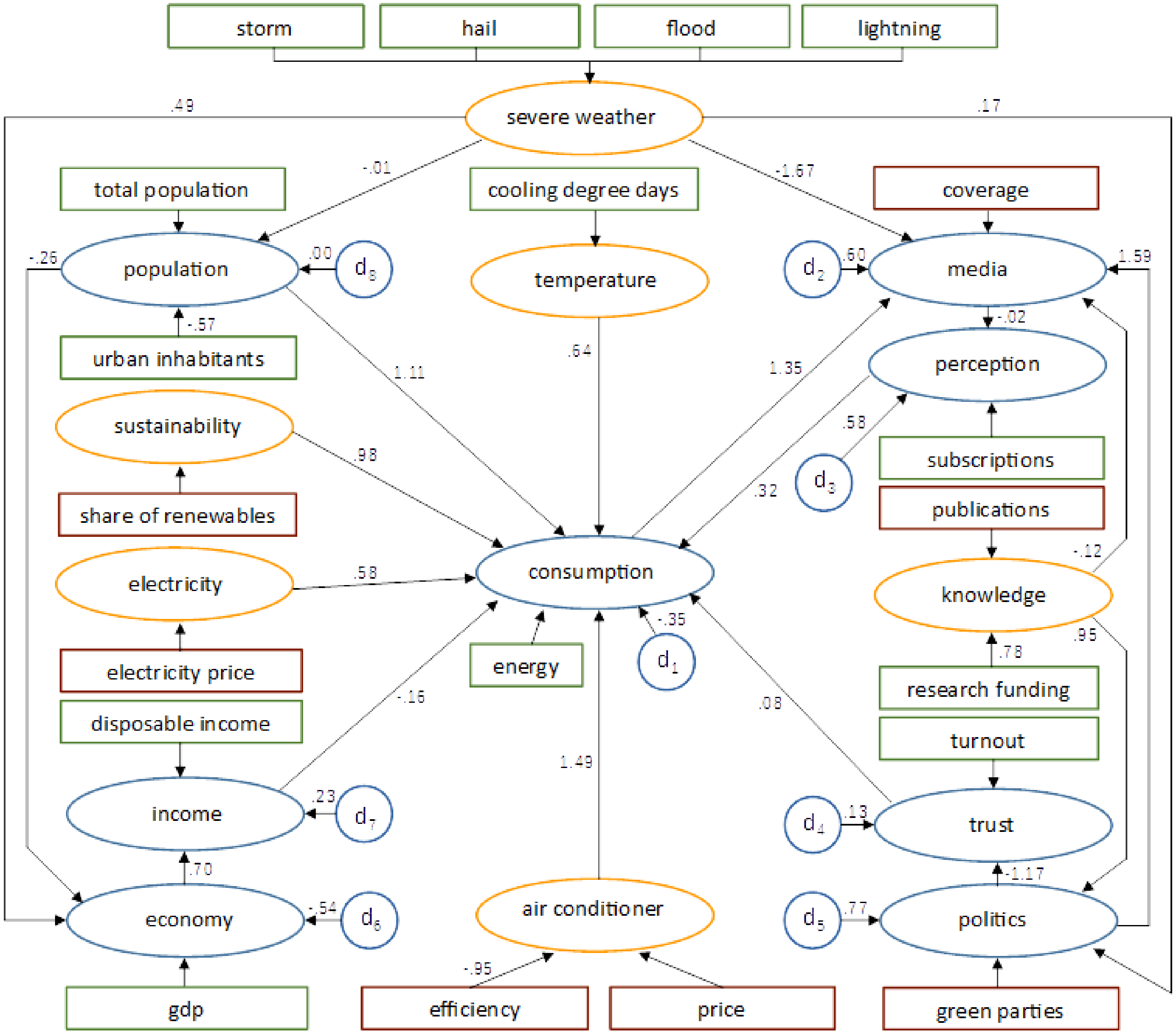

Figure 28: Structural equation model with loadings; orange ovals represent exogenous factors, blue ovals endogenous factors; green boxes represent material indicators, red boxes ideal indicators.

VA	Meaning	Unit	Miss	Source
weather	surface air temperature long term deviation	°C	--	EEA
	temperature change since 1979	°C	--	EDJN
	sea level variation per year	mm	4	NASA
	surface air relative humidity in august	%	19	Climate Change Service
	number of storms	#	--	Climate Change Service
	number of floods	#	--	Climate Change Service
	climate risk index	-	10	Germanwatch
	heating degree days	d	1	Eurostat
	cooling degree days	d	1	Eurostat
	number of lightnings	#	--	Rädler
	number of hails ≥ 2cm	#	--	Rädler
	number of winds ≥ $25ms^{-1}$	#	--	Rädler
electricity	electricity prices for houshold consumers	€/kWh	--	Eurostat
energy	share of energy from renewables	%	12	Eurostat
perception	share of readers of daily newspapers	%	5	Pew Research Center
media	newspaper articles covering climate	#	4	MeCCo
	level of media attention to climate change	%	18	cliSAP
air conditioner	producer price index for air-conditioning	2003	13	FRED (St. Louis)
	energy efficiency ratio for air-conditioner	EER	2	CEE
üolitics	room for climate in political parties	-	13	Klüver
	turnout parliamentary and presidential elections	%	--	IDEA
	representation of Greens in parliaments	%	--	Delwitt
economy	gross domestic product	€	--	Eurostat
	income in real terms per capita	€	9	Eurostat
	harmonized unemployment rate	%	1	FRED
	sales of air-conditioners	#	9	JRAIA
	stock of installed air-conditioners	#	9	IEA
	population of EU 28	#	--	Eurostat
	population of urban regions	#	23	Eurostat

population	number of 1.000 private households	#	8	Portdata
	median population 85 years or over	#	2	Eurostat
	death rate per a hundred thousand inhabitants	‰	4	Eurostat
public knowledge	funding for climate research	bn$	13	Overland
	scientific publications on climate change	#	5	Giupponi
	priority to combating climate change	%	22	Eurobarometer
consumption	energy consumption of industry	Mtoe	1	Odyssee
	residential electricity consumption per dwelling	kWh	8	Odyssee
	energy for space cooling per dwelling	kWh	21	Odyssee
	energy consumption of transport	Mtoe	1	Odyssee
	energy consumption of households	Mtoe	1	Odyssee
	energy consumption of services	Mtoe	1	Odyssee
	residential energy consumption per dwelling	Mtoe	8	Odyssee
	residential electricity consumption per dwelling	kWh	8	Odyssee
	energy for space heating per dwelling	toe	8	Odyssee
	energy for hot water per dwelling	toe	8	Odyssee
	energy for cooking per dwelling	toe	8	Odyssee
	energy for space cooling per dwelling	kWh	8	Odyssee
	energy for electric gadgets per dwelling	kWh	8	Odyssee
	energy for large electric machines per dwelling	kWh	10	Odyssee
	energy for lighting per dwelling	kWh	8	Odyssee
	energy for refrigerators per year	kWh	1	Odyssee
	energy for freezers per year	kWh	1	Odyssee
	energy for washing machines per year	kWh	1	Odyssee
	energy for dishwashers per year	kWh	1	Odyssee
	energy for TV per year	kWh	1	Odyssee
	energy for dryers per year	kWh	1	Odyssee
	energy for domestic transport	Mtoe	1	Odyssee
	energy for air transport	Mtoe	1	Odyssee

Figure 29: Category name, unit, and source of data used in the model for energy consumption in the years 1990 to 2018 including missing values.

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