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FELIX RICHTER, MALTE STEENBECK & MARKUS WILHELM
NUCLEAR ACCIDENTS AND POLICY:
NOTES ON PUBLIC PERCEPTION

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Nuclear Accidents and Policy:

Notes on Public Perception

Abstract: Nuclear energy is controversially discussed in many countries. Major nuclear accidents as recently in Fukushima set nuclear power plant security on top of the public agenda and increase pressure on policy makers to provide adequate reactions. Using data of the German Socio-economic Panel we analyze the effects of the accident in Fukushima and the following resolution on a nuclear phase-out plan by the German federal government on subjective perceptions using ordinary least squares and ordered logit estimates. We find strong evidence that the period after Fukushima increases the probability to report greater worries about the environment. Furthermore, we find evidence for an increase in reported levels of happiness and a decrease in the probability to be very worried about the security of nuclear power plants after the government's resolution on the nuclear phase-out.

Keywords: nuclear energy, nuclear accident, Fukushima, phase-out plan, life satisfaction, environment,

JEL: I31, N70, Q48

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1 Introduction

Nuclear energy is controversially discussed in many countries. Major nuclear accidents as recently in Fukushima set nuclear power plant security on top of the public agenda and increase pressure on policy makers to provide adequate reactions. In the case of Germany, the origins of these discussions and the formation of an anti-nuclear movement can be traced back to the 1970s. Following the 1986 Chernobyl nuclear disaster with large areas of Germany being affected by radioactive fallout, public opinion increasingly turned against this source of energy generation. A first act on nuclear phase-out passed by the Social Democratic/ Green Party coalition in 2002 was

dismissed by the Christian Democratic/ liberal coalition in September 2010. However, increasing opposition towards nuclear energy after the Fukushima catastrophe in March 2011 resulted in a change in policy. On June 6th 2011, the Christian Democratic/ liberal German government decided on a new accelerated phase-out with the final shutdown of eight power plants in August 2011 and a complete abandoning of nuclear energy by 2022.

In the light of the substantial public resistance against the use of nuclear energy the question arises as to what extend far-reaching events such as nuclear accidents or changes in nuclear policy are reflected in subjective assessment. Using data of the German Socio-economic Panel (SOEP) for the year 2011, we investigate the impact of the Fukushima accident and the subsequent decision on nuclear phase-out on reported subjective life satisfaction and concerns about the environment. In an additional analysis the phase-out effect is shown for a new variable of the SOEP capturing fears about nuclear power plant security. Our results can be summed up as follows: Whereas the time after the Fukushima accident resulted in a significant increase in environmental worries, a slightly positive effect can be found on life satisfaction. However, both subjective life satisfaction and concerns about the security of nuclear power plants turn out to be sensitive to the political decision on nuclear phase-out, resulting in higher levels of reported happiness and fewer worries about nuclear power station safety.

Berger (2010) analyzed the effects of the Chernobyl accident. While her results support the thesis that environmental concerns were affected by nuclear accidents

little evidence was found concerning an impact on reported happiness.¹ Further socioeconomic literature on the relationships between subjective life satisfaction respectively on concerns about the environment and nuclear accidents is rare. As the events in Fukushima happened too recently, existing works mainly focus on Chernobyl. An exception is Hommerich (2012), who investigates the effects of the Fukushima accident on trust and happiness in two Japanese regions. Danzer & Danzer (2011) test the long run influence of the Chernobyl accident on subjective life satisfaction in the Ukraine. As expected they find a negative impact on happiness for individuals exposed to the catastrophe. Remennick (2002) analyzes the health of Chernobyl survivors that immigrated into Israel whereas Bromet et al. (2000) focus on the happiness of local children that were infants or unborn at the time of the accident. Thematically related, Luechinger & Raschky (2009) analyze the effect of natural disasters on life satisfaction, but focus on flood catastrophes. The literature on the effects of general socioeconomic determinants of happiness is broader, including Easterlin (1995) on income, Clark & Oswald (1994) on unemployment status, or Frijters & Beatton (2012) on age as prominent representatives. Good surveys are provided by Diener et al. (1999) and Stutzer & Frey (2010), among others.

The remainder of the article is organized as follows: Section 2 presents our data source and describes the

¹ In an earlier working paper version Berger (2008) finds evidence on changes in subjective life satisfaction reported one year after the Chernobyl disaster. However, it is argued that these medium run changes are not necessarily related to the events of March 1986.

empirical strategy. Section 3 discusses the results of our multivariate analyses. The paper closes with a conclusion.

2 Data Sources and Empirical Strategy

We model the effects of the Fukushima nuclear accident and the subsequent changes in nuclear policy on life satisfaction as well as on concerns about the environment and fears about the safety of nuclear power plants. Following Berger (2010), our working hypothesis is that the accident has a significant impact on environmental concerns, i.e. leads to an increase in fears. In contrast, the nuclear phase-out could increase subjective life satisfaction and lead to a decrease in fears.

We use data from the SOEP v28-edition (SOEP, 2012), a population-representative panel survey conducted in Germany. Our constructed data set comprises the year 2011. To operationalize the subjective perception we use three different single-item measurements included in the SOEP: Both the worries about environmental protection and the concerns about the security of nuclear power plants are captured on an ordinal three category scale, originally coded "very worried", "slightly worried" and "not worried". For ease of interpretation, both variables were mirrored.² The more comprehensive question on life satisfaction in

² The exact passages in the questionnaire are: "What is your attitude towards the following areas - are you concerned about them (Environmental Protection; Security of nuclear Power Plants)?" Possible answers are "Very worried", "Slightly worried" and "Not worried".

general is answered on an 11-point scale ranging from "completely dissatisfied" to "completely satisfied".³

While the variables concerning environmental protection and life satisfaction in general are available for all waves of the panel, the question on worries about the security of nuclear power plants was first included in the SOEP surveys from April 2011. The main independent variables consist of dummy structures describing the various time periods of interest. We explain them in detail in the next section. Additionally we control for a set of common socioeconomic variables including age, age squared, health (only in estimations for happiness), gender, log of monthly household income, marital status, children in household, educational level, and labor market status in addition to federal state dummies and a regional dummy (east/west).

The empirical strategy consists of the following steps: First we estimate the effects of the Fukushima accident on our main dependent variable, worries about the environmental protection. As the SOEP interviews are spread over the year, we can interpret the period after the accident and the period after the resolution on the phase-out as quasi-exogenous treatments, using the period from the beginning of 2011 until the Fukushima disaster as a control group. We also provide a more differentiated version using monthly dummy variables. In the next step, we present a similar analysis using the reported levels of

³ The exact passages in the questionnaire are: "In conclusion, we would like to ask you about your satisfaction with your life in general. Please answer according to following scale: 0 means 'completely dissatisfied', 10 means 'completely satisfied'. How satisfied are you with your life, all things considered?"

subjective life satisfaction as dependent variable. Here we focus particularly on the period after the decision on nuclear phase-out, as Berger (2010) finds little evidence of an effect on reported happiness for the Chernobyl accident. Contrary to the 1986 events that caused nuclear fallout over parts of the country, Germany was less affected by the 2011 Fukushima accident so we have reasons to believe that a direct effect from the Fukushima accident on reported happiness is improbable. In a final step we use a new SOEP variable to investigate the effect of the government resolution on phase-out on the fears about nuclear power plant security.

3 Empirical Results

In this section we present our findings. Table 1 shows the main results for the specification where we assess the effects on reported worries about the environment. All reported parameters are marginal effects calculated from pooled cross-section ordered logit regressions. For clarity, we only report the marginal effects for the outcome "very worried". It is expected that any changes in fears related to the nuclear accident would predominantly appear in this category. The marginal effects for the control variables have the expected signs and magnitudes and are not reported.⁴

⁴ The tables can be obtained from the authors upon request.

Table 1: Marginal Effects of the probability of being "Very Worried" about the environmental protection after Fukushima: Pooled Cross section - Ordered Logit Estimation

Worries about environmental protection	Ordered Logit	
	A	B
Reference Period:		
<i>Before Fukushima nuclear disaster</i>		
02/01/2011 – 03/10/2011		
<i>Outbreak of the Fukushima crisis</i>	0.050***	
03/11/2011 – 06/05/2011	(0.011)	
<i>Nuclear Power Phase-out in Germany after Fukushima</i>		
06/06/2011 – 09/30/2011	-0.016	
	(0.012)	
Reference Period:		
02/01/2011 – 02/28/2011		
03/01/2011 – 03/10/2011		-0.007
		(0.019)
03/11/2011 – 03/31/2011		0.038**
		(0.016)
04/01/2011 – 04/30/2011		0.054***
		(0.016)
05/01/2011 – 05/31/2011		0.053***
		(0.016)
06/01/2011 – 06/05/2011		0.063
		(0.056)
06/06/2011 – 06/30/2011		-0.037**
		(0.018)
07/01/2011 – 07/31/2011		-0.020
		(0.021)
08/01/2011 – 08/31/2011		-0.002
		(0.020)
09/01/2011 – 09/30/2011		-0.010
		(0.021)
Observations	16181	16181
Pseudo R ²	0.016	0.016

Source: Own analysis, calculation and illustration, SOEP LONG Version, 2011.

Notes: Dependent variable: worries about the environmental protection (coded 1 - 3); marginal effects: probability of being "Very Worried" about the environmental protection; robust standard errors in brackets; coefficients of the models, with error probability in parentheses: ***p<0.01 - **p<0.05 - *p<0.1; cross section weights for all waves; controlled for other exogenous variables: Age, Age (squared), log Household Income, Child in Household, Marital Status, Employment Status, State Dummies and Regional Dummy (East).

Colum #A shows our benchmark results. We observe only the year 2011 and use a dummy structure to separate three different time periods: The period from the beginning of February until beginning of the Fukushima chain of accidents (used as reference outcome), the period directly after the accident and the time after the federal government's decision on the nuclear phase-out until the end of September. The parameter directly after the accident is positive and highly significant whereas the parameter of the nuclear phase-out shows no significance. Since we report marginal effects for the highest category, these results can be interpreted as follows: Compared to the period before Fukushima, being interviewed directly after the accident increases the probability of being "very worried" about the environment by about 5 percentage points. However, being interviewed after the nuclear phase-out does not change the probability to be "very worried" on a significant level.

In column #B we repeat this analysis using monthly time dummies instead of only three different time periods.⁵ Compared to the reference outcome (February), the remainder of March, as well as April and May result in a significant increase in the probability of being very worried about the environment. Furthermore, compared to the time before Fukushima, a significant negative change in the probability of being very concerned about the environment can be observed for the rest of June following the decision on nuclear phase-out. The effect is only significant in a

⁵ March and June are split in two parts to account for pre / post Fukushima (03/11/2011) and pre / post resolution on the phase-out (06/06/2011).

short time period directly after the decision, indicating a short run effect. Accordingly, the effect is not measurable in the more aggregated case in column #A.

Table 2 presents the results for our estimates on life satisfaction using the same dummy structure and time frame as presented in Table 1. As mentioned before, Berger (2010) finds little evidence on the existence of an effect of the Chernobyl nuclear disaster on subjective life satisfaction. However, since our models include both, the Fukushima accident as well as the subsequent decision on nuclear phase-out, we decided to check whether reported levels of happiness show sensitivity to any of the two events. As happiness is reported on an 11-point ordinal scale it is relatively safe to regard the variable as continuous. Following Ferrer-i-Carbonell & Frijters (2004) we hence estimate the model equations using ordinary least squares (columns #A and #B) and report ordered logit parameters as a robustness check (columns #C and #D). As in the previous models on environmental concerns we include additional socioeconomic control variables.⁶

For columns #A and #C, our dummy variable structure divides the 2011 sample period in three sub-periods: The period from the beginning of February until before Fukushima, the period directly after the accident and the period after the government's resolution on the nuclear phase-out. Compared to the reference period, we find evidence for an increase in reported levels of happiness by 0.211 scale points for the time after the decision on the phase-out. This sharp increase is also confirmed by the corresponding ordered

⁶ Results are available upon request.

logit parameter reported in column #C that equals the OLS coefficients in direction and significance. The period immediately after the Fukushima accident shows a slightly positive effect on life satisfaction which is difficult to explain, the corresponding ordered logit parameter reported in column #C is insignificant. It is possible that we observe some kind of anticipation effect of the nuclear phase-out resolution, as plans for the change in policy were discussed publicly before the actual governmental resolution. However, the evidence for such an effect is not very pronounced.

Table 2: Effects of the Nuclear Power Phase-out in Germany after Fukushima: Pooled Cross section - OLS vs. Ordered Logit Estimation

General Life Satisfaction	OLS		Ordered Logit	
	A	B	C	D
Reference Period: <i>Before Fukushima nuclear disaster</i> 02/01/2011 – 03/10/2011				
<i>Outbreak of the Fukushima crisis</i> 03/11/2011 – 06/05/2011	0.073* (0.043)		0.072 (0.048)	
<i>Nuclear Power Phase-out in Germany</i> 06/06/2011 – 09/30/2011	0.211*** (0.055)		0.261*** (0.064)	
Reference Period: 02/01/2011 – 02/28/2011				
03/01/2011 – 03/10/2011		-0.020 (0.069)		-0.060 (0.075)
03/11/2011 – 03/31/2011		-0.004 (0.062)		-0.038 (0.069)
04/01/2011 – 04/30/2011		0.080 (0.061)		0.081 (0.068)
05/01/2011 – 05/31/2011		0.134** (0.067)		0.132* (0.076)
06/01/2011 – 06/05/2011		0.252 (0.170)		0.260 (0.212)
06/06/2011 – 06/30/2011		0.236*** (0.083)		0.248*** (0.094)
07/01/2011 – 07/31/2011		-0.043 (0.093)		-0.050 (0.115)
08/01/2011 – 08/31/2011		0.336*** (0.099)		0.388*** (0.121)
09/01/2011 – 09/30/2011		0.301*** (0.109)		0.428*** (0.135)
Observations	14256	14256	14256	14256
Adjusted R^2	0.266	0.267		
Pseudo R^2			0.082	0.083

Source: Own analysis, calculation and illustration, SOEP LONG Version, 2011.

Notes: Dependent variable: general life satisfaction (coded: 0 – 10); robust standard errors in brackets; coefficients of the models, with error probability in parentheses: *** $p < 0.01$ - ** $p < 0.05$ - * $p < 0.1$; cross section weights for all waves; controlled for other exogenous variables: Health, Age, Age (squared), log Household Income, Child in Household, Marital Status, Employment Status, State Dummies and Regional Dummy (East).

In columns #B and #D, we employ the same monthly dummy structure as in column #B of table 1. Except for May, the months between the Fukushima accident and the nuclear phase-out decision do not imply any significant effects on happiness. Similar to the preceding more aggregated model (columns #A and #C), the significant coefficients for May

are difficult to explain (columns #B and #D). As outlined above, we might witness some kind of anticipation effect of the nuclear phase-out resolution. The results for the nuclear phase-out in comparison indicate strong positive effects on happiness for all month after the government resolution except for July that shows no significant deviation compared to the reference. Being interviewed in the months following the phase-out resolution raises the reported life satisfaction up to 0.336 scale points. These estimates are supported in sign and significance by the corresponding ordered logit parameters. Overall the evidence of nuclear accidents on life satisfaction is somewhat diffuse (cf. Berger, 2010). However, the effects of the nuclear phase-out on happiness are large, positive and significant.

As a final exercise we alter our model to include a new variable measuring the "worries about the security of nuclear power plants", recently included in the SOEP questionnaire directly after the Fukushima events. Hence, we only observe the period from April 2011 until the end of 2011. As we cannot account for the Fukushima accident, we only consider the two categories before the nuclear phase-out resolution on 06/06/2011, and after the announcement.

Table 3: Marginal Effects of the probability of being “Very Worried” about the security of nuclear power plants after the nuclear power phase-out in Germany after Fukushima: Pooled Cross section 2011 - Ordered Logit Estimation

Worries about the security of nuclear power plants	$\frac{\partial \Pr(y_i = \text{Not Worried})}{\partial x_i^j}$	$\frac{\partial \Pr(y_i = \text{Slightly Worried})}{\partial x_i^j}$	$\frac{\partial \Pr(y_i = \text{Very Worried})}{\partial x_i^j}$
Reference Category: <i>Fukushima nuclear crisis</i>			
Period of Time: 04/01/2011 – 06/05/2011			
Nuclear Power Phase-out in Germany after Fukushima : 06/06/2011 – 12/31/2011	0.072*** (0.012)	0.019*** (0.004)	-0.091*** (0.015)
Observations	4048	4048	4048
Pseudo R ²	0.034	0.034	0.034

Source: Own analysis, calculation and illustration, SOEP LONG Version, 2011.

Notes: Dependent variable: worries about the security of nuclear power plants (coded 1 - 3); marginal effects reported; robust standard errors in brackets; coefficients of the models, with error probability in parentheses: ***p<0.01 - **p<0.05 - *p<0.1; cross section weights for all waves; controlled for other exogenous variables: Age, Age (squared), log Household Income, Child in Household, Marital Status, Employment Status, State Dummies and Regional Dummy (East)

Table 3 shows the results of the estimation on concerns about the safety of nuclear power stations using a pooled cross-section ordered logit model. As in the previous models, the usual socioeconomic control parameters are included but not reported and are available upon request. Since we estimate only one category (without the reference outcome) we report the marginal effects for all three possible outcomes of the dependent variable. The results resemble our earlier findings on life satisfaction with the central result being the parameter in the last column: Being interviewed after the government’s resolution on nuclear phase-out reduces the probability to be very worried about the security of nuclear power plants by 9.1 percentage points. Accordingly, being interviewed after the announcement increases the probability of reporting no

worries or only slight concerns by 7.2, respective 1.9 percentage points. All effects are highly significant.

4 Conclusion

The use of nuclear power is often subject to controversial discussions. While widely accepted as a power source, it also faces strong public opposition in some countries. Major nuclear accidents as in Chernobyl (1986) or Fukushima (2011) set nuclear power plant security on top of the public agenda. In Germany, facing massive public pressure, a nuclear power phase-out plan was passed by the government in the aftermath of Fukushima 2011.

In this article, we analyze the effects of nuclear accidents and the phase-out on subjective perceptions in Germany. We use three single item measurements from the SOEP: concerns about the environment, concerns about the safety of nuclear power stations, and the overall reported life satisfaction.

We find that concerns about the environment are significantly higher directly after a nuclear accident, but that the phase-out decision does not change these concerns significantly. Our next model confirms earlier findings: There are no clear significant effects in the months after nuclear accidents on happiness. Nuclear accidents have no unambiguous effects on the reported life satisfaction. However, the effect of the phase-out policy is large, positive, and significant. This effect is also mirrored by a new variable in the SOEP, finding that the phase-out significantly reduces the reported concerns about nuclear power station safety.

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