DIW BERLIN

The Case of Fukushima

Natural Disaster, Policy Action, and Mental Well-Being

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1

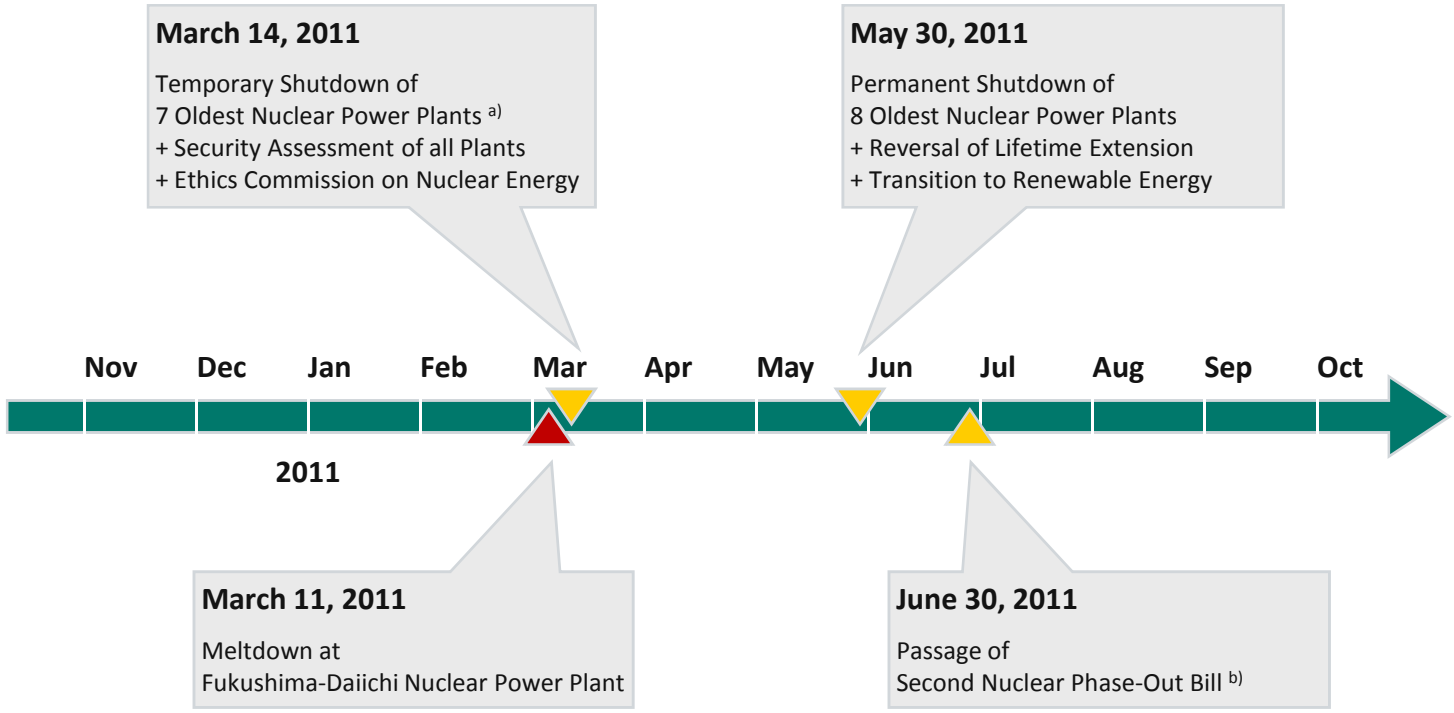
Background & Motivation

1 Background & Motivation

- On March 11, 2011, at 3pm JST, the Tohoku earthquake, magnitude 9.0, struck off the east coast of Japan at an underwater depth of about 30km.
- It triggered a gigantic tsunami with waves up to 40m.
- The tsunami's dimensions by far exceeded the safety measures of the Fukushima-Daiichi nuclear power plant whose 5.7m sea walls were easily topped by the up to 15m tsunami waves hitting the plant.
- After the failure of the cooling systems and a series of explosions, 3 of the 6 reactors fully melted down, releasing radioactive material.
- Fukushima was the second worst nuclear disaster after Chernobyl, leading to a reassessment of nuclear energy around the world.

1 Background & Motivation

In Germany, this reassessment of nuclear energy almost immediately lead to a turnaround in the energy policy of the conservative government.



Legend: Natural Disaster, Policy Action

a) Excludes Krümmel Nuclear Power Plant, which was already shut down, b) Carving the decisions of May 30, 2011, into law

1 Background & Motivation

- We estimate the effects of the Fukushima disaster on mental well-being in Germany, another industrialised country more than 5,500 miles away, where the objective tsunami risks did not increase due to the accident.
- Germany is an interesting case study as the immediate policy action taken by the conservative government was world-wide unique.
- We attempt to answer two research questions:
  1. Did the Fukushima disaster have (negative) effects on the mental well-being of individuals in Germany?
  2. Did the policy action taken by the conservative government in Germany alleviate some of these (negative) effects?
- We employ a broad rather than clinical definition of mental well-being, using measures of strong concern as measures of mental distress.

2

Literature Review

2 Literature Review

We add to the literature on the effects of natural disasters and terrorism on subjective well-being in general and on mental well-being in particular.

Subjective Well-Being & Mental Well-Being

- Frank (1981)
- Oswald (1997)
- Winkelmann and Winkelmann (1998)
- Frijters et al. (2004)
- Frank and Koss (2005)
- Frey et al. (2007)
- Clark et al. (2008, 2009, 2010)
- Glied and Frank (2009)
- Lu et al. (2009)
- Senik (2009)
- Clark and Senik (2010)
- Knabe et al. (2010)
- Luechinger et al. (2010)
- Ojeda et al. (2010)
- Cahit et al. (2011)
- Clark and Etilé (2011)
- …

Natural Disasters & Terrorism

- Luechinger and Raschky (2009)
- *Berger (2010)*
- Danzer and Danzer (2011)
- Draca et al. (2011)
- *Metcalfe et al. (2011)*
- Schüller (2012)
- …

Fukushima Disaster [a)]

- Yamamura (2012)
- Aoki and Rothwell (2013)
- Buesseler et al. (2013)
- Csereklyei (2013)
- Ohtake and Yamada (2013)
- Rehdanz et al. (2013)
- Richter et al. (2013)
- Rieu (2013)
- *Tiefenbach and Kohlbacher (2013)*
- Wang et al. (2013)
- …

We investigate for the first time the effects of the Fukushima disaster on mental well-being in another country.

Legend: Most of these studies have focused on Japan.

3

Data

3 Data

- We obtain panel data from the German Socio-Economic Panel (SOEP).
- The SOEP is a representative study of private households in Germany, covering almost 11,000 households and 20,000 individuals annually.
- It provides information on all household members, including Germans living in the old and new federal states, foreigners, and immigrants.
- In what follows, we exploit the panel dimension of the SOEP, focusing on individuals who were interviewed from 2009 to 2012.
  - 26,369 individual-year observations and 16,280 different individuals, of which 10,089 were interviewed from 2010 to 2011 without missings
  - 57,492 individual-year observations and 31,165 different individuals, of which 7,935 were interviewed from 2009 to 2012 without missings

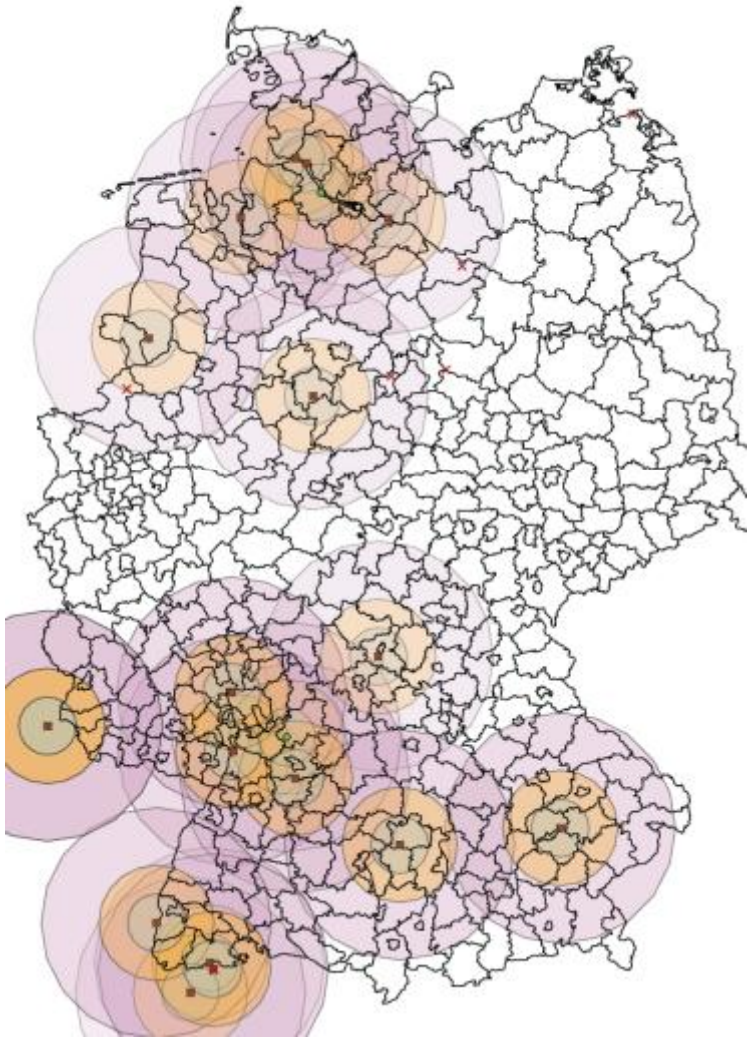
3 Data

- The dependent variable is being v*ery concerned about the environment*, which is the collapsed version of the 3-point Likert scale question that asks:

  What is your attitude towards environmental protection? Are you concerned? (a) Very concerned, (b) Somewhat concerned, (c) Not concerned at all

- Other dependent variables include:
  - Other strong concerns (health, job security, economy, crime)
  - Subjective well-being (satisfaction with life in general)
  - Affective well-being (happiness, sadness)
- The covariates include demographic, educational, and labour market characteristics which have been shown to affect the dependent variables.
- We also include the distance to the next nuclear power plant, risk aversion, cohort, and political party support to investigate effect heterogeneity.

3 Data



- This map shows the locations of nuclear power plants and waste sites in and around Germany.
- There are clusters of plants around Hamburg, Mannheim, and Fribourg.
- Beznau and Fessenheim are amongst the oldest nuclear power plants in the world and located near Fribourg.
- 57% of all individuals in the sample live within a 100km radius to a plant.
- Further, 28% and 9% live within a 50km and 25km radius to a plant, respectively.

Note: Circles indicate 100, 50, and 25km radii. Dots indicate nuclear power plants. Crosses indicate nuclear waste sites.

4

Empirical Model

4 Empirical Model

We employ the following difference-in-difference regression design:

$$y_{it} = \alpha + \beta_1(\text{PostMarch11}_{i,2011} \text{x} 2011) + \beta_2(\text{PostMay30}_{i,2011} \text{x} 2011) + \beta_3 2011 + \quad (1)$$
$$+ \beta_4 \text{PostMarch11}_{i,2011} + \beta_5 \text{PostMay30}_{i,2011} + \mathbf{X}_{it}'\gamma + \delta_y + \phi_m + t + \mu_i + \varepsilon_{it}$$

where

β_1:	average treatment effect on the treated of the disaster
β_2:	average treatment effect on the treated of the policy
$\mathbf{X}_{it}'$:	vector of observables [a)]
δ_y, ϕ_m:	year and month fixed effects
t:	linear time trend
μ_i:	individual fixed effects

$\text{PostMarch11}_{i,2011}$ and $\text{PostMay30}_{i,2011}$ are time-invariant dummies equal to one if the individual was interviewed after March 11 and May 30, 2011, respectively.

Legend: Includes the Euclidean distance between the household and the nearest nuclear power plant in and around Germany.

4 Empirical Model

- Intuitively, the natural disaster and the policy action have to be exogenous.
- The identifying assumption is that, conditional on $\mathbf{X}_{it}'\gamma$, δ_y, ϕ_m, t, and μ_i, the interview date is random and unrelated to the natural disaster.
- This is likely to be the case, given that, for the vast majority of interviews, an interviewer is physically present and interviews are scheduled in advance.
  - It is unlikely that the natural disaster had an effect on scheduling interviews as it was exogenous and unexpected, occurring on a Friday at 7.45am CET.
  - The vast majority of interviews is conducted during the first half of the year and observables are well balanced between treatment and control group.
- If the identifying assumption is satisfied, cross-section data would be sufficient. However, panel data allows us to dig deeper, in particular to investigate whether
  - unobservables matter by comparing results obtained by pooled OLS and FE.

5

Results

5.1. Fukushima

Short-Term Homogeneous Effects (2010-2011): Baseline Results

	Very Concerned About the Environment			
	OLS	**OLS**	**FE**	**FE**
$PostMarch11_{i,2011}$*2011 *("After Disaster")*	0.0644***	0.0639***	0.0713***	0.0713***
	(0.0147)	*(0.0147)*	*(0.0088)*	*(0.0088)*
$PostMay30_{i,2011}$ *2011 *("After Policy")*	-0.0753***	-0.0791***	-0.0984***	-0.0994***
	(0.0258)	*(0.0257)*	*(0.0159)*	*(0.0159)*
$PostMarch11_{i,2011}$	-0.0014	-0.0001		
	(0.0112)	*(0.0111)*		
$PostMay30_{i,2011}$	-0.0183	-0.0142		
	(0.0141)	*(0.0140)*		
2011	-0.0025***	-0.0024***	-0.0018***	-0.0018***
	(0.0008)	*(0.0008)*	*(0.0005)*	*(0.0005)*
Controls				
Demographic Characteristics	No	Yes	No	Yes
Educational Characteristics	No	Yes	No	Yes
Labour Market Characteristics	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes	Yes
R^2	*0.0036*	*0.0126*	*0.0061*	*0.0075*
N	***26,369***	***26,369***	***26,369***	***26,369***

Note: * p<0.1, ** p<0.05, *** p<0.01; standard errors are in parentheses and clustered at the interview date level. The treatment statuses are defined by $PostMarch11_{i,2011}$ and $PostMay30_{i,2011}$. They are based on whether the individual was interviewed after March 11 and after May 30, 2011, respectively. The dependent variable is a dummy variable which equals one if the individual is very concerned about the environment. Each model is equivalent to the regression model in equation (1).
Source: SOEP v29, 2010-2011, unbalanced panel, own calculations

Short-Term Homogeneous Effects (2010-2011): Robustness Checks (1/2)

	Very Concerned About the Environment			
	Uses Alternative Policy Action Date	**Excludes Movers Outside 50km Radius to Birth Place**	**Excludes Movers in Previous Time Period**	**Excludes Postal Interviews**
	(1)	**(2)**	**(3)**	**(4)**
$PostMarch11_{i,2011}$*2011 *("After Disaster")*	0.0610***	0.0874***	0.0752***	0.0794***
	(0.0086)	*(0.0121)*	*(0.0090)*	*(0.0149)*
$PostMay30_{i,2011}$*2011 *("After Policy")*		-0.1338***	-0.1114***	-0.1203***
		(0.0213)	*(0.0163)*	*(0.0246)*
$PostJune30_{i,2011}$*2011	-0.0959***			
	(0.0213)			
Controls				
Demographic Characteristics	Yes	Yes	Yes	Yes
Educational Characteristics	Yes	Yes	Yes	Yes
Labour Market Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes	Yes
R^2	*0.0061*	*0.0130*	*0.0082*	*0.0144*
N	***26,369***	***12,375***	***25,974***	***13,356***

Note: * p<0.1, ** p<0.05, *** p<0.01; standard errors are in parentheses and clustered at the interview date level. The treatment statuses are defined by $PostMarch11_{i,2011}$ and $PostMay30_{i,2011}$. Column (1) uses June 30, 2011, as the relevant policy action date. Column (2) excludes individuals that moved outside a 50km radius to their birth place. Column (3) excludes individuals that moved in the previous time period. Column (4) excludes postal interviews. Otherwise, each model is equivalent to the full FE model of the baseline results.
Source: SOEP v29, 2010-2011, unbalanced panel, own calculations.

Short-Term Homogeneous Effects (2010-2011): Robustness Checks (2/2)

	Very Concerned About the Environment			
	Adds Linear Time Trend After Disaster	**Adds Linear Time Trend After Policy**	**Adds Quadratic Time Polynomial**	**Uses Balanced Panel**
	(5)	**(6)**	**(7)**	**(8)**
$PostMarch11_{i,2011}$*2011 *("After Disaster")*	0.0717***	0.0733***	0.0880***	0.0713***
	(0.0094)	*(0.0088)*	*(0.0140)*	*(0.0088)*
$PostMay30_{i,2011}$*2011 *("After Policy")*	-0.0997***	-0.1144***	-0.0587***	-0.0994***
	(0.0159)	*(0.0154)*	*(0.0277)*	*(0.0159)*
Controls				
Demographic Characteristics	Yes	Yes	Yes	Yes
Educational Characteristics	Yes	Yes	Yes	Yes
Labour Market Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes	Yes
R^2	*0.0075*	*0.0086*	*0.0078*	*0.0075*
N	***26,369***	***26,369***	***26,369***	***20,178***

Note: * p<0.1, ** p<0.05, *** p<0.01; standard errors are in parentheses and clustered at the interview date level. The treatment statuses are defined by $PostMarch11_{i,2011}$ and $PostMay30_{i,2011}$. Column (5) adds a linear time trend which starts after the natural disaster. Column (6) adds a linear time trend which starts after the policy action. Column (7) adds a quadratic time polynomial. Column (8) uses a balanced rather than unbalanced panel. Otherwise, each model is equivalent to the full FE model of the baseline results.
Source: SOEP v29, 2010-2011, unbalanced panel, own calculations.

Short-Term Heterogeneous Effects (2010-2011): Baseline Results (1/2)

	Very Concerned About the Environment		
	Supports Social Democrats/ Greens	**Is Risk Averse**	**Is Above 40 Years**
	(1)	**(2)**	**(3)**
$PostMarch11_{i,2011}$*2011*Heterogeneity *("After Disaster")*	-0.0219	-0.0156	0.0145
	(0.0215)	*(0.0193)*	*(0.0160)*
$PostMay30_{i,2011}$*2011*Heterogeneity *("After Policy")*	-0.0444	0.0479	-0.0182
	(0.0342)	*(0.0303)*	*(0.0256)*
Controls			
Demographic Characteristics	Yes	Yes	Yes
Educational Characteristics	Yes	Yes	Yes
Labour Market Characteristics	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes
R^2	*0.0094*	*0.0092*	*0.0077*
N	***5,888***	***13,052***	***19,480***

Note: * p<0.1, ** p<0.05, *** p<0.01; standard errors are in parentheses and clustered at the interview date level. The treatment statuses are defined by $PostMarch11_{i,2011}$ and $PostMay30_{i,2011}$. *Heterogeneity* refers to the respective heterogeneity measure used, which is written in the respective column header. All heterogeneity measures are lagged by one period. All two-way interactions are included. Otherwise, each model is equivalent to the full FE model of the baseline results.
Source: SOEP v29, 2010-2011, unbalanced panel, own calculations.

Short-Term Heterogeneous Effects (2010-2011): Baseline Results (2/2)

	Very Concerned About the Environment		
	Within 50km to Nuclear Plant	**Within 50km-80km to Nuclear Plant**	**Next Nuclear Plant Among 8 Oldest**
	(1)	**(2)**	**(3)**
$PostMarch11_{i,2011}$*2011*Heterogeneity *("After Disaster")*	-0.0117	0.0482**	0.0023
	(0.0177)	*(0.0188)*	*(0.0143)*
$PostMay30_{i,2011}$*2011*Heterogeneity *("After Policy")*	-0.0078	-0.0725***	-0.0676**
	(0.0282)	*(0.0294)*	*(0.0282)*
Controls			
Demographic Characteristics	Yes	Yes	Yes
Educational Characteristics	Yes	Yes	Yes
Labour Market Characteristics	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes
R^2	*0.0079*	*0.0084*	*0.0081*
N	***26,369***	***26,369***	***25,766***

Note: * p<0.1, ** p<0.05, *** p<0.01; standard errors are in parentheses and clustered at the interview date level. The treatment statuses are defined by $PostMarch11_{i,2011}$ and $PostMay30_{i,2011}$. *Heterogeneity* refers to the respective heterogeneity measure used, which is written in the respective column header. All heterogeneity measures are lagged by one period. All two-way interactions are included. Otherwise, each model is equivalent to the full FE model of the baseline results.
Source: SOEP v29, 2010-2011, unbalanced panel, own calculations.

5

Results

5.2. Fukushima vs. Chernobyl

Results: Fukushima vs. Chernobyl

Long-Term Homogeneous Effects (2009-2012): Baseline Results

	Very Concerned About the Environment				
	OLS (2009-2012)	**FE (2009-2012)**		**OLS (1984-1989)**	**FE (1984-1989)**
PostMarch11i,$_{2011}$*2011	0.0712***	0.0797***	PostApril26i,$_{1986}$*1986	0.1025***	0.1213***
("After Disaster")	*(0.0116)*	*(0.0104)*	*("After Disaster")*	*(0.0175)*	*(0.0151)*
PostMay30$_{i,2011}$ *2011	-0.0871***	-0.1078***	PostJuly15$_{i,1986}$*1986	-0.0183	-0.0247
("After Policy")	*(0.0191)*	*(0.0156)*		*(0.1686)*	*(0.0251)*
2010	0.0338***	0.0348***	1985	-0.0291***	-0.3000***
	(0.0054)	*(0.0042)*		*(0.0100)*	*(0.0088)*
2011	0.0003	0.0092	1986	-0.0869***	-0.1034***
	(0.0082)	*(0.0068)*		*(0.0116)*	*(0.0102)*
Controls					
Demographic Characteristics	Yes	Yes		Yes	Yes
Educational Characteristics	Yes	Yes		Yes	Yes
Labour Market Characteristics	Yes	Yes		Yes	Yes
Year Fixed Effects	Yes	Yes		Yes	Yes
Month Fixed Effects	Yes	Yes		Yes	Yes
Linear Time Trend	Yes	Yes		Yes	Yes
R^2	*0.0121*	*0.0087*		*0.0655*	*0.0281*
N	**57,492**	**57,492**		***62,540***	***62,540***

Note: * p<0.1, ** p<0.05, *** p<0.01; standard errors are in parentheses and clustered at the interview date level. Each model is equivalent to the full FE model of the baseline results.

6

Discussion & Conclusion

6 Discussion & Conclusion

- We demonstrated that the Fukushima disaster increased the share of individuals in Germany that are very concerned about the environment.
  - This effect lies between 6 to 7ppt depending on the specification.
- However, the policy action taken by the conservative government in Germany did not only decrease, but more than offset the initial rise in mental distress.
  - This effect lies between 8 to 10ppt depending on the specification.
- We employ the concept of Quality-Adjusted Life Years (QALY) to quantify the initial rise in mental distress (a crude back-of-the-envelope calculation):

  1QALY ≈ 100,000€. Averaged, strong concern results in a 1ppt QALY reduction.
  There are 68.5mio Germans ≥ 17 years. Then 6ppt ≈ 4.1mio Germans ≥ 17 years.

  Therefore, ((0.01*4,100,000)/4) = 10,250QALY costs.
  Therefore, ((10,250*100,000)/4,100,000) = 250€ costs per capita.

6 Discussion & Conclusion

- There are three important take-away´s from this study:

1. It seems that disasters do not only have negative local effects, but also impose negative external effects on other countries, even in case that these country are unaffected and distant.

2. It seems that negative external effects in other countries exist even in case that a disaster in a country does increase the objective risk of a similar disaster in another country.

3. It seems that immediate and credible policy action can remediate such negative external effects.

Thank you for your attention.

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