

Anticipated Impacts of Nuclear Accidents

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Who Am I

- 15 years experience at the Nuclear Regulatory Commission (NRC) with a focus on nuclear accident consequence analysis
 - Consequence analyst for the NRC cost-benefit analysis on the Expedited Transfer of Spent Fuel (COMSECY-13-0030)
 - Consequence analyst for various research projects (e.g., State-of-the-Art Reactor Consequence Analyses, NUREG-1935; Spent Fuel Pool Scoping Study, NUREG-2161)
 - Dose analyst responding to the Fukushima Daiichi nuclear disaster through the NRC Incident Response Center
 - Author of the theory manual for the MACCS severe accident consequence analysis code
 - I help direct the development for the MACCS code
- BS and MS in Nuclear Engineering (UW-Madison)
- PhD in Decision Science and Operations Research, Industrial and Systems Engineering (UW-Madison)
 - Dissertation titled, “Fukushima-informed Recovery and Cost Assessment: A Proposed Approach to Estimating the Cost of Nuclear Disasters”

Outline

- Introduction
- Property Damage (Market Impact)
- Economic Disruptions (Market Impact)
- Nuclear Plant Damages (Market Impact)
- Expenditures (Market Impact)
- Environmental Damage (Non-Market Impact)
- Burden of Societal Disruptions (Non-Market Impact)
- Health Effects (Non-Market Impact)
- A Practitioner's Thoughts

Introduction

- Accounting for a comprehensive set of nuclear accident impacts is important for regulatory decision-making.
- Nuclear accidents, particularly those with widespread contamination, have numerous adverse impacts.
- Goal of presentation: categorize and present the broad range of adverse impacts resulting from nuclear accidents.

Introduction

Breakdown of Market and Non-Market Impacts of a Nuclear Accident

Market	Non-Market
Property damage (physical, contamination, interdiction, stigma)	Environmental damage (radiation-induced, disaster-related)
Economic disruptions (Losses to businesses, consumers, workers, and supply chains)	Burden of societal disruptions (related to stigma and evacuation / displacement)
Nuclear Plant (property damage and economic disruption)	Health effects (radiation-induced, disaster-related)
Expenditures (e.g., emergency response activities, relocation, medical services, decontamination-related activities, compensation and litigation system)	

Property Damage (Market Impact)

- Real estate
 - Impacted by land interdiction, contamination, and stigma
 - Impacted by local market conditions
 - Business closures lead to loss of local employment opportunities, goods, and services
 - Loss of local functional services (e.g., utilities, health care, schools)
- Agriculture
 - Crop losses impacted by food interdiction
- Other tangible losses due to contamination
- Nuclear plant damage

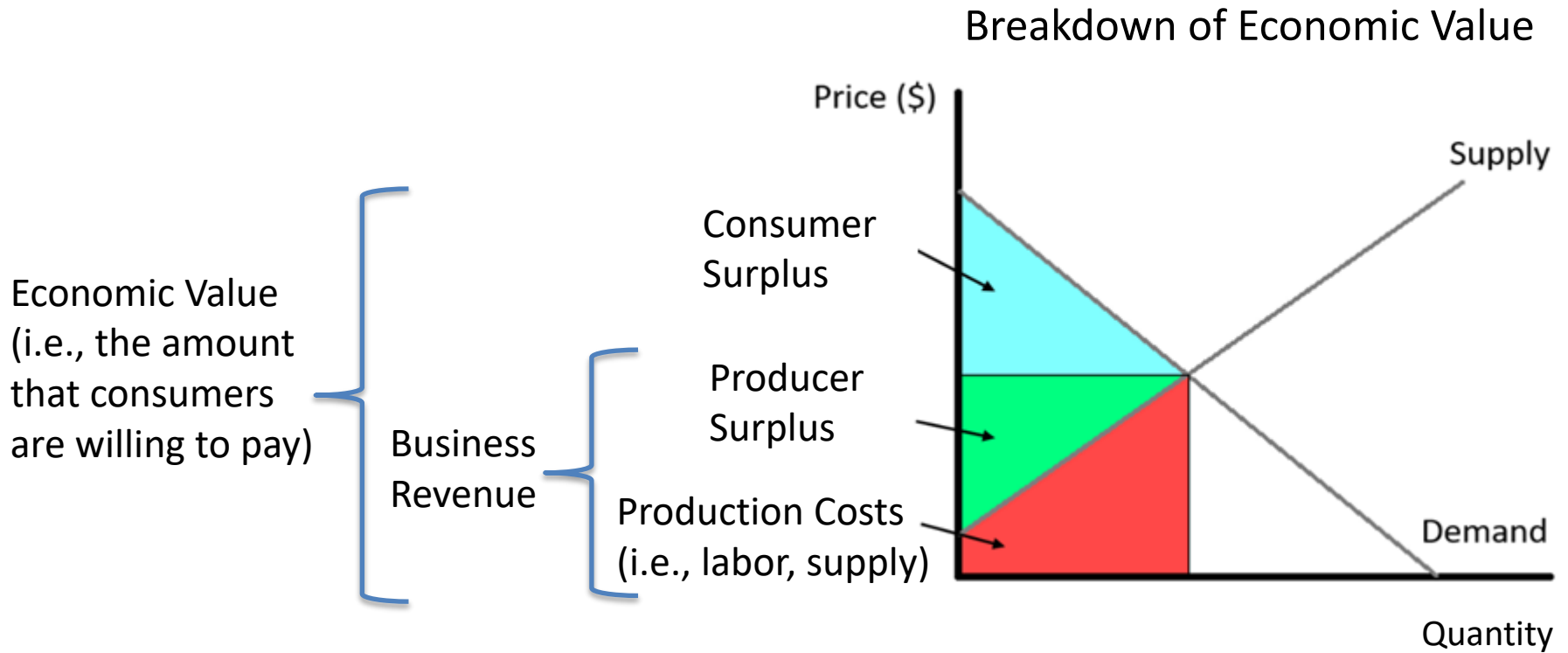
Property Damage (Market Impact)

- Two major offsite areas: interdicted and unrestricted areas
 - Land interdiction makes property unusable
 - Interdiction prevents upkeep, causing faster depreciation
 - Interdiction can increase the perception that an area is hazardous
 - Interdicted areas may have little to no salvage value

Economic Disruptions (Market Impact; 1/2)

- Economic activity requires:
 - businesses that profit from operations
 - workers that earn wages and benefits
 - suppliers (and others) that sell their commodities to the businesses
 - customers that purchase the goods or services
- Economic disruptions can occur when restrictions disrupt one of these activities

Economic Disruptions (Market Impact; 2/2)



Nuclear Plant Damages (Market Impact)

- An accident causes both property damage and economic disruption
 - Physical damage and contamination may lead to unusable property
 - While the plant is not operating, there is a replacement energy cost to meet the electricity demand the plant would normally produce.
- If the accident causes minor damage (i.e., no permanent shutdown), costs include
 - Restoration costs and the replacement energy cost for the outage.
- If the accident causes a permanent shutdown, cost include
 - Increased cost to decommission the plant, the decreased salvage value of the plant, and the replacement energy cost for the plant.
- If the accident causes widespread nuclear plant shutdowns, costs include
 - Decreased plant asset values and increased replacement energy costs for the affected nuclear plants.

Expenditures:

Decontamination-Related Activities (1/2)

- Widespread Decontamination Campaign
 - Decontamination
 - Waste storage
 - Waste transportation
 - Waste disposal
 - Other support activities (e.g., community outreach, the development of plans and guidelines, research and development, worker training and acquisition, contract management and work verification)

Expenditures:

Decontamination-Related Activities (2/2)

- In addition to decontamination waste, other sources of contaminated waste include:
 - Trash collection, agricultural, sewage / wastewater, deteriorating buildings, household belongings, disaster debris
- Uncertain policies and level of preparedness will affect timeliness and costs
 - Extent of decontamination
 - Acceptable cleanup level
 - Necessity of interim storage
 - Final waste disposal site
 - Decontamination pilot program

Expenditures: Relocation Expenses

- Displaced individuals
 - Food
 - Transportation
 - Temporary housing
 - Moving costs
 - Household goods
 - Comparable replacement dwelling
 - Ancillary housing costs (e.g., closing costs, mortgage interest, rental / down payment assistance)
- Displaced businesses
 - Operating expenses during a transitional period
 - Temporary place of business
 - Employee training
 - Office supplies

Expenditures: Medical Costs

- Medical care for the sick and elderly
 - Short-term care during evacuation and at shelters.
 - Long-term living assistance for those separated from their support networks due to the evacuation.
- Medical care for general population
 - Care for displaced individuals with degraded physical or mental conditions.
 - Periodic medical screenings for radiation-induced health effects, and care and treatment should they arise.

Other Expenditures

- Emergency Response Activities
 - Unified command and other field offices
 - Emergency operations centers (Federal, state, and local)
 - Offsite response organizations
- Compensation and Litigation System
 - Court and attorney fees
 - Administration of claims

Environmental Damage (Non-Market Impact)

- Short-term radiation effects
 - High doses can kill plants and animals (e.g., Chernobyl’s “red forest”).
- Long-term radiation effects
 - Studies observe negative effects on abundance, distribution, and life history of certain plants and animals (e.g., insects, birds).
 - Mammals have flourished in exclusion areas without humans.
- Physical damage
 - No direct physical destruction of environment.
 - Heavy decontamination (e.g., stripping topsoil, felling trees) is harmful in areas it is used.
 - Light decontamination (e.g., grass cutting, washing, sweeping) is more widely used and has minimal impact.

Burden of Societal Disruptions (Non-Market Impact)

- Displacement of large populations creates significant personal and social disruptions
- Types of impacts:
 - Psychological distress (increased post-traumatic stress disorder and other disorders)
 - Behavior and lifestyle changes (increased sleep issues, diabetes, dyslipidemia, overweight, and substance abuse)
 - Loss of livelihood (loss of homes, jobs, lifestyle)
 - Dysfunction in families and communities (conflicts regarding risk perception, compensation, and stigma)
 - Diminished standard of living (worse living conditions, severe health care issues, and social isolation have been major causes of death among elderly)

Health Effects (Non-Market Impact)

- Disaster-related health effects
- Radiation-induced health effects
 - Stochastic effects (e.g., cancer)
 - Deterministic effects (e.g., radiation sickness)

A Practitioner's Thoughts

- A nuclear accident with widespread contamination has many types of societal consequences
 - Property damage
 - Economic disruptions
 - Nuclear plant damages
 - Expenditures
 - Emergency response activities
 - Relocation expenses
 - Medical costs
 - Decontamination-related activities
 - Compensation and litigation system
 - Environmental damage
 - Burden of societal disruptions
 - Health effects
- Valuations that can better reflect the full impact, including their extent and duration, may help improve analyses for practitioners.