



The MACCS Alternative Economic Consequences Model aka “Regional Disruption Economic Impact Model (RDEIM)”

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Overview

- Objectives for RDEIM
- Current MACCS Economic Model
- RDEIM Overview
 - Input-Output Modeling
 - Data Sources
- Loss estimation in RDEIM
- Status of Integration



Goals for RDEIM

- Estimate reduction of GDP including direct, indirect, and induced impacts on economy using state of practice macroeconomic modeling techniques
- Create a consistent model application across different geographic regions and time periods
- Provide technically sound and consistent estimates of economic impacts from potential nuclear power plant accidents
- Provide an economic model that enables the MACCS analyst some flexibility but is not so complex as to require economics expertise



Current MACCS Economic Model

- The original MACCS “Cost-Based” economic model estimates offsite costs associated with protective actions.
- Includes the following categories
 - Evacuation/relocation costs on a per diem basis
 - Long-term relocation
 - Decontamination of property
 - Loss of use
 - Expected return on investment (property value)
 - Depreciation on improvements to property
 - Condemnation of property
 - Disposal of contaminated farm products (crops and dairy products)
- Does not calculate indirect costs due to business disruption and lost income



New Regional Disruption Economic Impact Model

- The new GDP-Based economic model is based on the existing Regional Economic Accounting Tool (REAcct) which utilizes current state-of-practice Input-Output methodology
 - Improves the business disruption components of the MACCS economic model
 - Estimates direct, indirect, and induced GDP losses
 - Direct losses are to the affected region.
 - Indirect losses are to the remainder of the economy.
 - Induced losses are related to spending of workers whose earnings are affected
- Includes “Tangible Wealth” losses



Comparison of Current and Alternative Economic Models

Current Model	RDEIM Model
Evacuation/relocation costs	Evacuation/relocation costs
Long-term relocation costs	Long-term relocation costs
Decontamination cost	Decontamination cost
Depreciation on property improvements	Depreciation on property improvements
Value of condemned property	Value of condemned property
Expected return on investment	GDP losses, including direct, indirect, and induced
Disposal of contaminated crop and dairy products	

Input-Output Methodology

- Represents flow of products between sectors of economy based on actual transactional data
- Linear, allows fast computation, can be analytically understood
- Effects of local changes to the regional or national levels can be estimated using multipliers
- BEA maintains National and Regional Input-Output accounts

Industries	Industries						Households
	Agriculture, mining, and utilities	Construction	Manufacturing	Trade	Transportation and warehousing	Services	
Agriculture, mining, and utilities	1.0776	0.0274	0.0728	0.0152	0.0201	0.0155	0.0321
Construction	0.0188	1.0066	0.0085	0.0065	0.0131	0.0113	0.0089
Manufacturing	0.0843	0.1876	1.1915	0.0659	0.1354	0.0630	0.1235
Trade	0.0661	0.1469	0.1031	1.0858	0.1015	0.0745	0.2068
Transportation and warehousing	0.0484	0.0390	0.0430	0.0447	1.1215	0.0256	0.0460
Services	0.3633	0.6684	0.4447	0.5587	0.6250	1.7214	1.1816
Households	0.2256	0.4460	0.2653	0.3572	0.4333	0.3327	1.2829
Total	1.6585	2.0759	1.8636	1.7768	2.0166	1.9113	1.5989

Direct Losses

- MACCS determines whether grid element is interdicted
- The average annual GDP per worker in industry i :

$$v_i = \frac{Y_i}{E_i}$$

Y_i = national annual GDP
for industry i

E_i = national employment
for industry i

- The rate of direct value added losses for industry i in grid element r :

$$v_{i,r}^D = e^{g(t_I - t_0)} v_i l_{i,r}$$

g = GDP growth rate

t_I = accident year

t_0 = base year

$l_{i,r}$ = number of employees in
industry i in grid element

Direct Losses (cont'd)

- The cumulative losses for industry in in grid element r:

$$\Delta V_{i,r}^D(T) = e^{g(t_I - t_0)} v_i l_{i,r} \int_0^T s_r(t) e^{(g-\rho)t} dt$$

Where ρ = social discount rate

T_r = max duration of local loss

s = disruption function

$$s_r = \begin{cases} 1, & t \leq T_r \\ 0, & t > T_r \end{cases}$$

- Direct Losses for the entire affected area:

$$\Delta V^D(T) = e^{g(t_I - t_0)} \sum_I v_i \sum_R l_{i,r} \int_0^T s_r(t) e^{(g-\rho)t} dt$$

Total, Indirect, and Induced Losses

- Total impact includes direct, indirect, and induced losses

$$\Delta V^T(T) = e^{g(t_I - t_0)} \sum_I v_i m_i^I \sum_R l_{i,r} \int_0^T s_r(t) s_N(t) e^{(g-\rho)t} dt$$

where

$$s_N = \begin{cases} 1 - \frac{t}{T_N}, & t \leq T_N \\ 0, & t > T_N \end{cases}$$

- Substituting m_i^I for Type II multipliers yields total impact excluding induced losses. Subtracting the direct losses from this expression provides the indirect losses

$$\Delta V^I(T) = e^{g(t_I - t_0)} \sum_I v_i \sum_R l_{i,r} \int_0^T s_r(t) (s_N(t) m_i^I - 1) e^{(g-\rho)t} dt$$

Economic Sectors

Industry	Partial County Weighting	
	Area	Population
Agriculture, forestry, fishing, and hunting	X	
Mining	X	
Utilities	X	
Construction		X
Manufacturing		X
Wholesale trade		X
Retail trade		X
Transportation and warehousing	X	
Information		X
Finance and insurance		X
Real estate and rental leasing		X
Professional, scientific, and technical services		X
Management of companies and enterprises	X	
Administrative and waste management services	X	
Educational services		X
Health care and social assistance		X
Arts, entertainment, and recreation		X
Accommodation and food services		X
Other services, except government		X
Federal Government		X
State and Local Government		X



Input Parameters

- Maximum Loss Calculation Timeframe
 - Max duration of local impacts
 - Max duration of national impacts
- GDP Growth Rate
 - Used to escalate GDP from base year to accident year
 - Accounts for GDP growth rate over duration of losses
- Social Discount Rate
 - Allows for benefits and costs that occur in different time periods to be compared directly by expressing their value in present terms
 - Social rate of time preference
 - Social opportunity cost of capital



Maximum Duration of Local and National Economic Impacts

- This model contains two time recovery parameters to specify recovery speed:
 - The maximum duration of impacts at the local level, T_R
 - The maximum duration of impacts at the national level, T_N
- Serves as an upper bound. Only comes into play if the area is abandoned or if recovery of land usage takes longer than the loss-calculation-duration value
- Data used to evaluate time frames for economic recovery were obtained from:
 - The length of U.S. recessions
 - Past disruption events, like Hurricane Katrina
 - Similar models
- A value of 10 years is recommended for T_R and 3 years for T_N



GDP Growth Rate and Social Discount Rate

- GDP Growth Rate
 - Historic is 3.3%
 - GDP growth rate estimated by the Congressional Budget Office is 2.2 – 2.4% per year
- Social Discount Rate
 - Office of Management and Budget (OMB) Circular A-4 advises using 3% and 7% discount rates for regulatory analyses
 - When "regulation primarily and directly affects private consumption..., a lower discount rate, 3%, is appropriate." The 3% discount rate is based on real returns to 10-year Treasury notes.



Input Parameter Values and Bounds

	Recommended Value	Lower Bound	Upper Bound
Real GDP Growth Rate (%/yr)	2.3	0	10
Social Discount Rate (%/yr)	3	0	10
Depreciation Rate (%/yr)	20	0	100
Maximum Duration of Local Impact (yr),	10	1	30
Time at which National Economy recovers (yr)	3	1	10

Sources: historic data (US GDP growth rates (BEA), duration of recessions), existing literature (social discount rate, loss calculation duration (COCO-2)), government policies and circulars (OMB Circular A-94)



Input Parameters for GDP Model

- Six new parameters were added for GDP model
 - Duration of regional economic impacts
 - Duration of national economic disruption
 - A multiplier that affects whether land is condemned or decontaminated
 - Social discount rate (discount rate used for social investments)
 - GDP growth rate
 - Accident year

Values to right are recommended

Value of dollar corresponds to year of database (2011)

Model Basis

Enter Comments:

ECON_RGDR (y)

ECON_NTDR (y)

ECON_MULT (-)

Real [0., 1000.] dimensionless

Land condemnation multiply factor. Used in case that land is to be decontaminated when cost exceeds land value.

Default Gross Domestic Product Parameters

Enter Comments:

ECON_DEF_DRT (-)

ECON_DEF_GRT (-)

ECON_DEF_AYR (-)

Real [0., 0.1] dimensionless

Default social discount rate over the economic impact duration as a fraction.

Change Units Make Uncertain OK Cancel

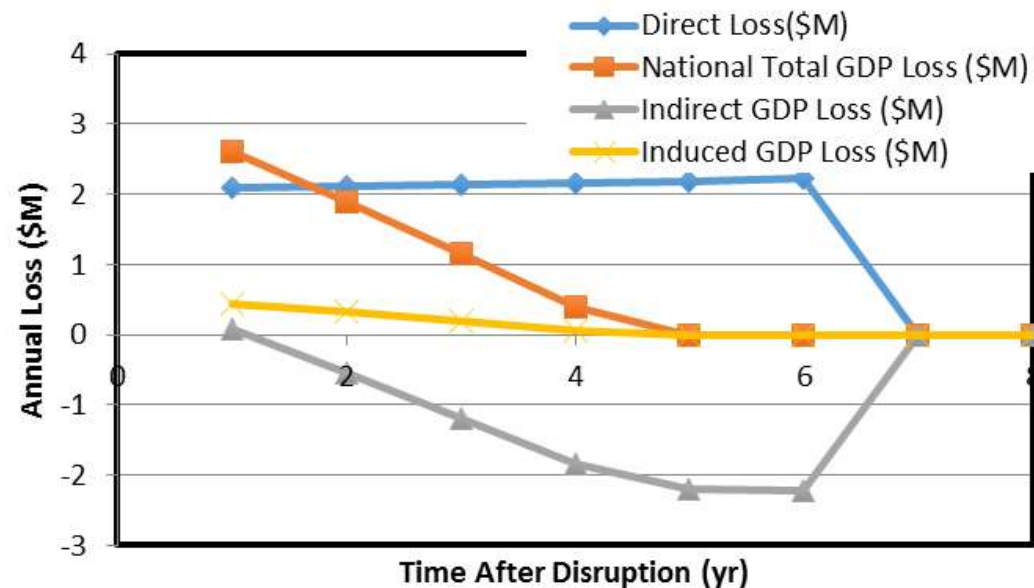


Simple RDEIM Example Calculation

Assumptions

- One industry (utilities) in one county is disrupted for 6 years
- Duration of national economic disruption is set to 4 years
- GDP growth rate is set to 3.3%
- Social discount rate is set to 2.0%

Annual GDP Losses



- Direct losses increase slowly then recover after year 6
- National total losses decrease linearly and fully recover after year 4
- Induced GDP loss also recovers after year 4
- Indirect losses are negative for most of the years



Peer Review Committee

- To confirm that integration of the new model into MACCS is suitable to estimate offsite cost impact from business disruption
- Consisted of 3 economic experts
 - Dr. Jeff Werling, University of Maryland
 - Mr. Neil Higgins, Public Health England
 - Dr. Haydar Kurban, Howard University
- Major Recommendations
 - Eliminate double counting by developing an algorithm to adjust multipliers based on size of affected area
 - Regional multipliers approach the national multipliers when the size of the area approaches zero
 - Regional multipliers approach unity when size of the area approaches that of the U.S.
 - Account for faster recovery of national economy



Status of Economic Model Development

- Implementation of the RDEIM model in MACCS is complete
 - Revision of model parameters to avoid double counting may require some additional work
 - Public version of SecPop (4.3) creates site data compatible with RDEIM
- Peer review process was highly valuable and resulted in significant changes to original model concept
- Verification and assessment is just beginning
- Goal is to release fully assessed model by end of calendar year



Acronyms

- BEA – Bureau of Economic Analysis
- DHS – Department of Homeland Security
- DOE – Department of Energy
- EPA – Environmental Protection Agency
- FEMA – Federal Emergency Management Agency
- GDP – Gross Domestic Product
- MACCS – MELCOR Accident Consequence Code System
- NNSA – National Nuclear Security Agency
- RDEIM – Regional Disruption Economic Impact Model



References

- Bureau of Economic Analysis (BEA). “RIMS II An Essential Tool for Regional Developers and Planners.” U.S. Department of Commerce. November 5, 2012.
- Bu.edu, 'U.S. Department Of Commerce Bureau Of Economic Analysis Regional Input-Output Modeling System (RIMS II) » Economic & Social Impact » Boston University'. N.p., 2015. Web. 25 Oct. 2015.



PRC Recommendations



Double-Counting

- The net total requirements type I multipliers are calculated as follows:

$$m_i = m_i^{I,N} - m_i^{I,R} + 1$$

- Using these multipliers allows excluding the part of what is normally called indirect effects that occur in the impacted area and therefore become direct and eliminates the concomitant double counting.



PRC Recommendations

- Economic losses should account for losses in wealth
 - Value of condemned property
 - Depreciation on property improvement
- Use different disruption durations for regional and national loss calculation



Use the National Industry-by-Industry Total Requirement (TRII) Table in a Closed Economy

- Convert the change in regional value added to change in regional gross output using the national industry output to value added ratio from the industry IO table.
- The regional gross output loss can then be multiplied by the national total requirements industry by industry coefficients (multipliers) for all industries in the economy. Summing these modified coefficients up would give you each industry's

$$m_i^{I,N} = \frac{Y_i}{V_i} \tilde{m}_i^I = \frac{Y_i}{V_i} \sum_j b_{i,j} \frac{V_j}{Y_j}$$

Total Requirements Table

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