*Household Dislocation Algorithm 2: An OLS through the Origin Approach**

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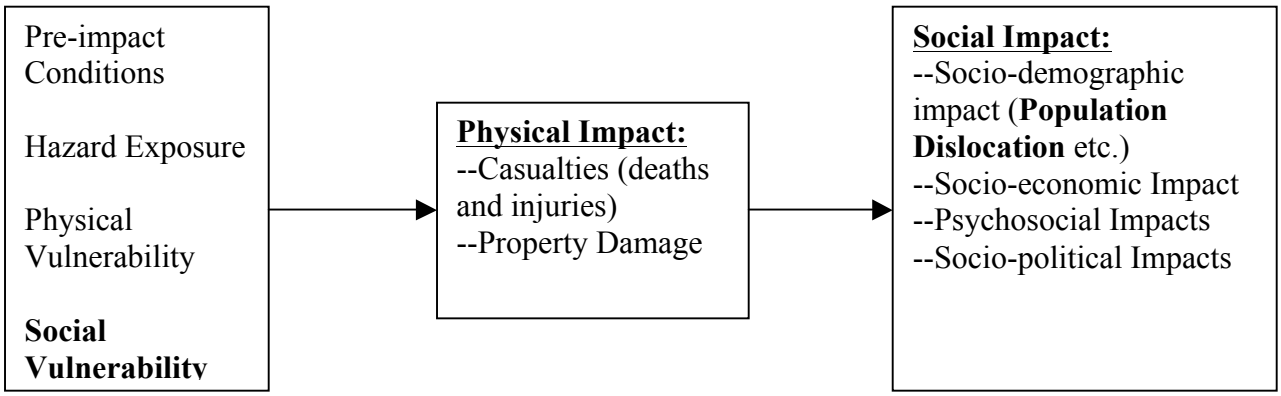
Household Dislocation Algorithm 2: An OLS through the Origin Approach

The disaster impact can be viewed as the result of interactions among three systems—the earth's physical system, the human social system, and the constructed system (Mileti, 1999). To understand the full nature of disaster impacts, we need to also understand better the nature of the social systems that are utilizing the built environment (buildings, transportation networks, infrastructure systems). Like the built environment, the social systems that produce and utilize that environment are far from homogeneous. They differ in their size, form and structure, in their access to scarce resources, such as wealth, power, social status and information, and in many other ways. These differences can shape and influence the nature of disaster impact—or again, the broader consequences of disasters. Estimates of population dislocation—one of the social impacts—will be inadequate if they are merely dependent on physical damages as demonstrated in the HAZUS model. Thus, this population dislocation algorithm is developed based upon not only the fragility of physical environment, but also the social factors and processes that generate vulnerability in terms of a person's or group's capacity to anticipate, cope with, resist and recover from the impact of a natural hazard (Blakie et al., 1994). These capacities are contingent upon a host of factors such as economic status and ethnicity that determine access to the scarce resources in the society.

Figure 1. The disaster impact model (Lindell & Prater, 2003)



Basic logic behind this approach:

The model is developed by employing the OLS regression method including two additional specifications, the interaction terms and regression through the origin. This model is based on two assumptions. The first assumption is that the social factors are nested in and interact with the damage factor. Here the effects of social factors on the dislocation become stronger, either positively or negatively, as the level of damage increases. The second assumption—the household dislocation is zero if there is no damage to residential structures—is met by regression through the origin. The model is specified as the following equations. The coefficients of five interaction terms are all significant at .05 level.

$$Y_{bg_k} = \left(b_1 + b_2 X_{2bg_k} + b_3 X_{3bg_k} + b_4 X_{4bg_k} + b_5 X_{5bg_k}\right) X_{1bg_k}, \text{ or}$$

$$Y_{bg_k} = b_1 X_{1bg_k} + b_2 X_{1bg_k} X_{2bg_k} + b_3 X_{1bg_k} X_{3bg_k} + b_4 X_{1bg_k} X_{4bg_k} + b_5 X_{1bg_k} X_{5bg_k}$$

In the equations the dependent variable Y_i is the percent of dislocated households in block group k. The independent variable X_{1bg_k} represents the damage level of all residential buildings in block group k, while other independent variables X_{2bg_k}, X_{3bg_k}, X_{4bg_k}, and X_{5bg_k} represent the social characteristics for block group k.

The OLS through the Origin Dislocation Algorithm

I. Base data requirements.

1. **Census data, at block group level:** In the HAZUS package, the data at Census tract are used to estimate possible dislocation household. Block group data are used here to estimate more detailed information thereby facilitating planning within local communities and counties. The following are the data needed for the dislocation algorithm, and are similar to those used in the social vulnerability algorithms. They are provided in the excel spreadsheet for Shelby County (they originally were generated by Steve French's group).

   Variable name — Variable definition
   - TOTPOP → Total Population
   - P_BLACK → Total Population -- Blacks Alone
   - TOT_HH → Total No. of Households
   - MEDHHINC → Median Household Income in dollars
   - TOT_HU → Total Housing Units
   - H_VAC → No. of Vacant Housing Units
   - H_SFDET → No. of Housing Units in Structures with 1 Detached Dwelling Unit

   The above data are employed to calculate the following socioeconomic variables for a certain block group k in the impacted area.

   Variable name — Variable definition
   - $\%BLACK_{bg_k}$ → Percent of Black alone population in block group k
   - $\%VAC_{bg_k}$ → Percent of vacant housing units in block group k
   - $MHHIK_{bg_k}$ → Median Household Income in thousand dollars in block group k
   - $\%SFDET_{bg_k}$ → Percent of Housing Units in Structures with 1 Detached Dwelling Unit in block group k

2. **From the inventory data:** The algorithm is based on damage to <u>residential structures</u> only. It is therefore critical that MAEViz be able to clearly identify residential structures and that residential structures be clustered into their respective census block-group areas. Here the damage variable is represented by the percent value loss of all residential structures in block groups. The percent of building value loss in block group k ($\%VLOSS_{bg_k}$) is estimated first by using the SE-2 Fiscal Impact Analysis Algorithms from Steve French and then the percent value loss of individual buildings are aggregated and averaged at the block group level, as shown in Step 1 and Step 2.

Step 1: Calculate Direct Economic Damage to building j

$$DED_j = \sum_{i=1}^{n} p(DS_i) \times DF_i \times Bldg\_Val_j$$

Where,

DED_j = Direct Economic Damage

$p(DS_i)$= probability of the building being in Damage State i

DF_i= Damage Factor i from Hueste et al.

$Bldg\_Val_j$ = Building Value for Building j from Inventory Database

Step 2: Calculate the average percent building value loss in block group k

$$\%VLOSS_{bg_k} = \frac{\sum_{j=1}^{m} DED_j}{\sum_{j=1}^{m} Bldg\_Val_j} \times 100$$

Where m = the number of buildings in the block group k.

II. Process for estimating dislocated households for block groups and the whole impacted area:

1. **Calculate percent of dislocated households for block group k:** The percent of dislocated households for block group k ($PDisHh_{bg_k}$) is calculated with the following equation. The required inputs are described in the base data requirements.

   - $PDisHh_{bg_k} = (\%VLOSS_{bg_k}) \times [b_1 + b_2 \times (\%BLACK_{bg_k}) + b_3 \times (\%VAC_{bg_k}) + b_4 (MHHIK_{bg_k}) + b_5 (\%SFDET_{bg_k})]$

   The required coefficients are listed in **Table 1.**

   Table 1. Default values of coefficients.

Coefficients	Default Values
b_1	0.99459
b_2	-0.00255
b_3	-0.01397
b_4	0.01114
b_5	-0.00297

2. **Calculating number of dislocated households for block group k:** After percent of dislocated households for each block group ($PDisHh_{bg_k}$) is calculated, the block groups with dislocation greater than 100% are adjusted at 100% and the block groups with dislocation lower than 0% are adjusted at 0%. Then the number of dislocated households for block group k ($DisHh_{bg_k}$) is calculated with the adjusted $PDisHh_{bg_k}$ ($PDisHhadj_{bg_k}$).

- $DisHh_{bg_k} = \left(PDisHhadj_{bg_k}\right) \times \left(TOT\_HH_{bg_k}\right)/100$

  Where $TOT\_HH_{bg_k}$ = total number of households in block group k.

3. **Calculating total number of dislocated households for a certain jurisdiction covering p block groups:** The total number of dislocated households ($TotDH$) in a certain jurisdiction covering **p** block groups is calculated as the following.

- $TotDh = \sum_{k=1}^{p} DisHh_{bg_k}$

III. Expected output:

1. First there should be a report of dislocated household by block group and the total number of dislocated household at county level. See Appendix 3.
2. Second, there should also be a map of number of displaced household by block group (using $DisHh_{bg_k}$). See Appendix 4.
3. Third a map of percent of displaced household within the block group (using $PDisHhadj_{bg_k}$). See Appendix 5.

Appendix 1. Variable List

Variable Name	Description	Note
TOTPOP	Total Population	2000 Census (from Dr. French)
TOT_HH	Total No. of Households	2000 Census (from Dr. French)
TOT_HU	Total Housing Units	2000 Census (from Dr. French)
H_SFDET	No. of Housing Units in Structures with 1 Detached Dwelling Unit	2000 Census (from Dr. French)
P_BLACK	Total Population -- Blacks Alone	2000 Census (from Dr. French)
MEDHHINC	Median Household Income in dollars	2000 Census (from Dr. French)
H_VAC	No. of Vacant Housing Units	2000 Census (from Dr. French)
$PDisHh_{bg_k}$	Percent of dislocated households for block group k	See Section II. 1.
$PDisHhadj_{bg_k}$	Adjusted percent of dislocated households for block group k	See Section II. 2.
$DisHh_{bg_k}$	Number of dislocated households for block group k	$DisHh_{bg_k} = (PDisHhadj_{bg_k}) \times (TOT\_HH_{bg_k})/100$
$TotDh$	Number of dislocated households for a jurisdiction covering **p** block groups	$TotDh = \sum_{k=1}^{p} DisHh_{bg_k}$
The following 5 are defined for Estimation Procedure Section II. 1. only.		
$\%VLOSS_{bg_k}$	Percent of building value loss for block group k	See Section I. 2.
$\%BLACK_{bg_k}$	Percent of Black alone population in block group k	[(P_BLACK)/(TOTPOP)]*100
$\%VAC_{bg_k}$	Percent of vacant housing units in block group k	[(H_VAC)/(TOT_HU)]*100
$MHHIK_{bg_k}$	Median Household Income in thousand dollars in block group k	(MEDHHINC)/1,000
$\%SFDET_{bg_k}$	Percent of Housing Units in Structures with 1 Detached Dwelling Unit in block group k	[(H_SFDET)/(TOT_HU)]*100

Appendix 2. Example Calculations for population dislocation:

The following is the hypothetical damage and social characteristic for a certain block group:

Block Group	Structure	Direct Economic Damage to the Building	Pre-impact Building Value	TOT_HH	TOT_POP	$\%VLOSS_{bg_k}$	$\%BLACK_{bg_k}$	$\%VAC_{bg_k}$	$MHHIK_{bg_k}$	$\%SFDET_{bg_k}$
471570013004	1	10,000	60,000	449	1152	70.835	54.7743	4.460	25.9110	78.8732
	2	70,000	80,000							
	3	100,000	120,000							
	4	36,000	50,000							
	5	29,000	40,000							
	…	…	…							
	…	…	…							

1. Calculate percent of dislocated households for block group k:

$$PDisHh_{bg_k} = \left(\%VLOSS_{bg_k}\right) \times \left[b_1 + b_2 \times \left(\%BLACK_{bg_k}\right) + b_3 \times \left(\%VAC_{bg_k}\right) + b_4\left(MHHIK_{bg_k}\right) + b_5\left(\%SFDET_{bg_k}\right)\right]$$

= (70.835)*[0.99459+(-0.00255)*(70.835)+(-0.01397)*(54.7743)+(0.01114)*(4.460)+(-0.00297)* (78.8732)]

= 59.99 %

2. Calculating number of dislocated households for block group k:

$$DisHh_{bg_k} = \left(PDisHhadj_{bg_k}\right) \times \left(TOT\_HH_{bg_k}\right)/100$$

= 59.99 * 449 / 100

= 269.355 dislocated households

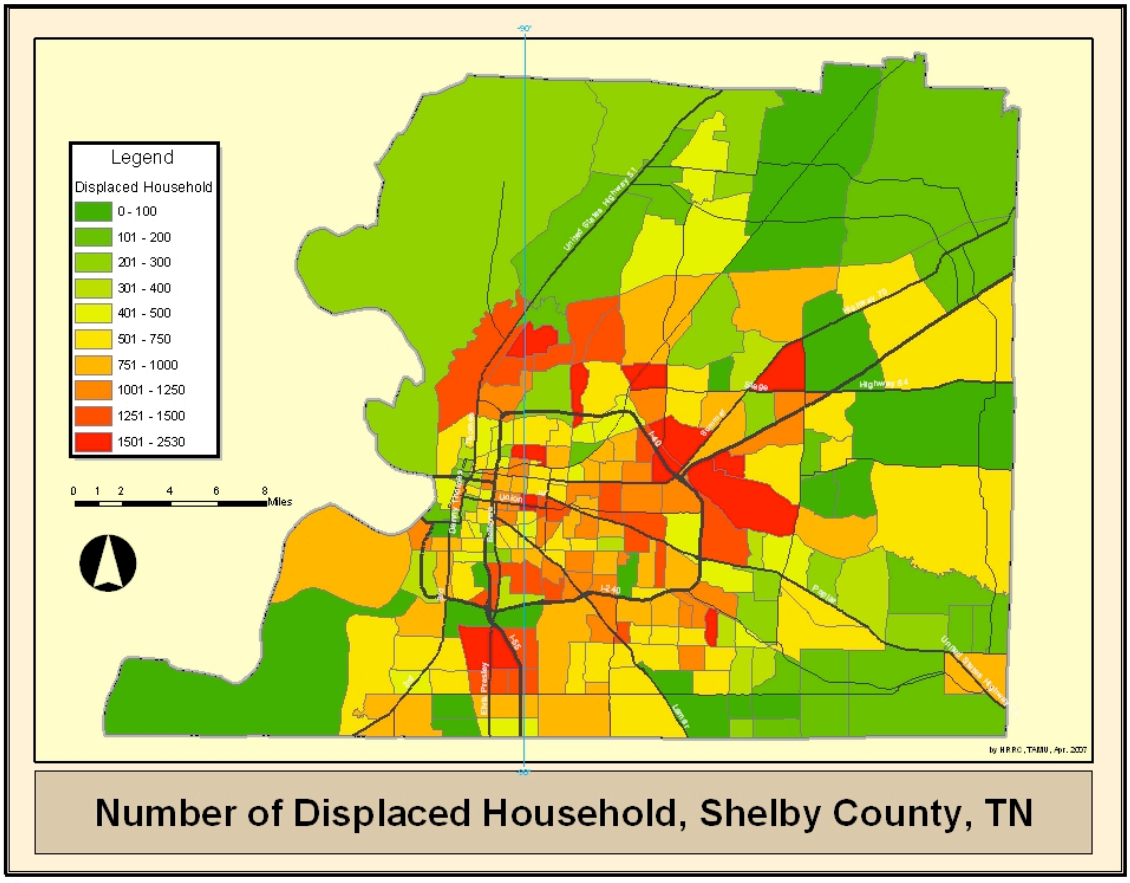
3. Calculating total number of dislocated households for a certain jurisdiction covering p block groups:

$$TotDh = \sum_{k=1}^{p} DisHh_{bg_k}$$

Appendix 3. Example of a fictions report of displaced household by jurisdiction (Shelby county) and by census block group.

	Number of Displaced Household	Percent of Displaced Household
Shelby County, TN		
	153232	46%
Block Group		
47157XXXXXXXX	383	73%
47157XXXXXXXX	453	68%
47157XXXXXXXX	494	59%
47157XXXXXXXX	231	71%
47157XXXXXXXX	673	58%
47157XXXXXXXX	1592	69%
……..		
47157XXXXXXXX	797	55%
47157XXXXXXXX	921	59%
47157XXXXXXXX	858	59%

Appendix 4 Example Number of Dislocated Household Map



Appendix 5 Example of Percent of Dislocated Household Map