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Manual for the Computation of the Disaggregate County-Level Truck Flows and Explanation of Model Calibration

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TxDOT Project 5-4713-01: Implementing a Truck Travel Database

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MANUAL FOR THE COMPUTATION OF DISAGGREGATE COUNTY-LEVEL TRUCK FLOWS AND EXPLANATION OF MODEL CALIBRATION

INTRODUCTION

Truck data is critical to transportation planning in any region. Inter-city and interstate truck flows have an important impact on traffic volumes, the mix of traffic, and experienced level of congestion on the state-maintained infrastructure. In Technical Report 0-4713-R1 entitled *"Development of Sources and Methods for Securing Truck Travel Data in Texas"*, a multinomial logit approach was proposed to estimate county level truck travel data from the publicly available 1997 Commodity Flow Survey (CFS) and IMPLAN data over the short term. Although not a required research product, the modeling approach was considered very useful to TxDOT. The objective of this manual is to explain how to use the calibrated multinomial logit (MNL) models to generate disaggregate county-level truck flows for Texas and to present a detailed explanation of the required steps to calibrate the MNL models in the future.

COMPUTATION OF DISAGGREGATE COUNTY-LEVEL TRUCK FLOWS

This section of the manual describes the steps involved in applying the calibrated multinomial logit (MNL) models to generate county-level truck flows for Texas in Excel, as well as the required format changes to the Excel workbooks to allow the data to be exported to the Access truck travel database developed as part of this research.

Step 1: Copy and Update the Attraction and Production Distribution Flow Workbooks

Copy the files "Step 1 Attraction Flow Distribution.xls" and "Step 1 Production Flow Distribution.xls" to the computer's hard drive.

Update both the Attraction and Production Flow Distribution workbooks with the latest Commodity Flow Survey (CFS) information. In the 1997 CFS, this information could be extracted from "StatesTbl15(1997): Shipment characteristics by 2 digit commodity and mode of transportation" and in the 2002 CFS from "Table 17: Shipment Characteristics by Destination State, Two-Digit Commodity and Mode of Transportation of Origin."

For the Attraction Flow Distribution workbook, the truck tonnage and value by commodity originating in Texas and destined for each state has be to extracted and entered in the Attraction Flow Distribution workbook (see screenshot on opposite page).

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For the Production Flow Distribution workbook, the truck tonnage and value by commodity destined for Texas originating from each state has be to extracted and entered in the Production Flow Distribution workbook (see screenshot on opposite page).

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Step 2: Copy and Update the Remaining Workbooks

Once the analyst has updated the Attraction and Production Flow Distribution workbooks, the subsequent steps are:

- 1. Copy the remaining files on the CD to the same folder as the Attraction and Production Flow Distribution workbooks.
- 2. Open "Step 2 State to Texas County Flows". A text message will appear similar to those on the opposite page (depending on the Excel version used). Click "Update" or "Yes" depending on the message.
- 3. Save the file and exit.
- 4. Open "Texas County to State Flows.xls" and follow sub-steps (1) to (3).
- 5. Repeat sub-steps (1) to (3) for all the "Intercounty commodity" files also.

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Step 3: Export the Truck Travel Data to Access

Once all the tonnage values for State-to-Texas county, Texas county-to-state, and intercounty commodity truck flows have been updated, the truck travel data needs to be exported to the truck travel database developed in Access for use in the Statewide Analysis Model (SAM). The following steps are required to format the Excel workbooks and to import the data into Access.

Step 3(a): Format the Excel Workbooks

- 1. Open "Step 2 State to Texas County Flows.xls". Click "Don't Update" or "No" when asked to update the file again.
- 2. Select all the data by Clicking in the upper left corner of the worksheet.
- 3. Copy and Paste Special the data to the same workspace by Clicking Edit Copy Edit Paste Special. Check the radio button Values and Click OK (see screenshot on the opposite page).

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4. Delete Columns A (labeled Destination State:Texas) and B (labeled Agriculture), and the NEW¹ Columns G (labeled State-County Centroidal Distance), H (labeled Fractional Attraction), and I (labeled Exp(U)). These columns are highlighted with red font (see screenshot on the opposite page).

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Columns G, H, and I after Columns A and B have been deleted.

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- 5. Select all the data again by Clicking in the upper left corner of the worksheet. Then Click Data Filter Auto Filter (see screenshot on the opposite page).
- 6. With all the data still selected, Click on the arrow next to DEST_ID. In the drop down box, highlight (Blanks) (see screenshot on the opposite page).

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- 7. Delete all the rows that contain data (i.e., row numbers will be yellow) by Selecting all the rows and Clicking Edit Delete Row. Also, Delete all empty columns that have filters.
- 8. Click again on the arrow next to DEST_ID and highlight "All". Then Click Data Filter Auto Filter to exit the filter mode.
- 9. Repeat these steps for each of the state worksheets.

To format the Step 2 Texas County to State Flows workbook, repeat Steps 1 to 4. For Step 5, select the ORIGIN_ID to filter the "Blanks" instead of the DEST_ID. Repeat the remaining Steps 6 to 9.

To format the Intercounty "Commodity" workbooks, repeat Step 1 and 2. For Step 3, erase Column A (labeled County), Column B (labeled County to Texas "Commodity"), and Column C (labeled County). Subsequently delete the NEW columns G, (labeled State to County Centroidal Distance), H (labeled Fractional Attractions), and I (labeled Exp(U)). These columns are highlighted in yellow. Repeat the remaining Steps 4 to 9.

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Step 3(b): Import the Truck Travel Data into Access:

- 1. Copy the Truck Travel Database (i.e., Truck Travel Database.mdb) on the CD to the computer's hard drive.
- 2. Open Truck Travel Database.mdb in Access by Clicking File Open, Highlighting Truck Travel Database in the Message Box and Clicking Open.
- 3. When the Security Warning "This file may not be safe if it contains code that was intended to harm your computer. Do you want to open this file or cancel the operation?" (see screenshot on the opposite page) appears, Click Open.
- 4. Click on File Get External Data Import. In the Import dialogue box, highlight the Files of Type as Microsoft Excel (*.xls) and highlight any of the previously formatted Excel workbooks (i.e., Texas County to State Flows). Click Import (see screenshot on the opposite page).





- 5. When the Import Spreadsheet Wizard dialogue box appears, select the first worksheet to be imported (e.g., Alabama). Then click Next (see screenshot on the opposite page).
- 6. When the next Import Spreadsheet Wizard dialogue box appears, the option "First Row Contains Column Headings" should already be selected. Click Next. If the dialogue box states the following: "The first row contains some data that can't be used for valid Access field names. In these cases, the wizard will automatically assign valid field names", close the application and return to the Excel workbooks. Make sure the worksheets are formatted appropriately. Do not allow the Access wizard to automatically assign valid field names (see screenshot on the opposite page).

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- 7. When the next Import Spreadsheet Wizard dialogue box appears, Select "In an Existing Table" and Highlight TruckData from the drop-down list box. Click Next.
- 8. When the next Import Spreadsheet Wizard dialogue box appears, Click Finish.

Repeat Steps 1 to 8 to import all the worksheets in the Texas County to State Flows workbook, all the worksheets in the State to Texas County Flows workbook, and the truck travel data in the 9 Intercounty commodity workbooks.

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EXPLANATION OF MODEL CALIBRATION

BACKGROUND

In TxDOT Technical Report 0-4713-R1 entitled "Development of Sources and Methods for Securing Truck Travel Data in Texas", a multinomial logit (MNL) approach was presented to estimate county level truck travel data from the publicly available Commodity Flow Survey (CFS) and IMPLAN data over the short term. MNL models were first calibrated at the state-level and then used to estimate truck flows at the county level. Two state-level MNL models were developed for each commodity category included in the statewide analysis model (SAM):

- The *MNL production flow distribution model* estimates the fraction of the total productions in a state moving to each attraction state by truck based on the attributes of the attraction states and inter-state centroidal distance that serves as a proxy for the generalized cost of transportation.
- The *MNL attraction flow distribution model* estimates the fraction of the total attractions in a state originating from each of the production states by truck based on the relative production levels of the origin states and the inter-state centroidal distance that serves as a proxy for the generalized cost of transportation.

The calibrated state-level MNL production and attraction flow distribution models are then used to estimate Texas county-to-county, state-to-Texas county, and Texas county-to-state truck flows.

The steps and sub-steps followed in calibrating the models and computing the county level truck flows for Texas are as follows:

- Step 1: Extract state-level commodity flows by truck mode for each commodity group to estimate production flow distribution and attraction flow distribution.
- Step 2: Calculate the fractional production and attraction flows for each state and commodity group.
- Step 3: Compute utility values for production flow distribution and attraction flow distribution
- Step 4: Develop state-to-state centroidal distance matrix.
- Step 5: Conduct linear regression analysis
 - (a) Production flow distribution model:
 Dependent variable utility for commodity flows to attraction states
 - Independent variables distance, percentage attraction level
 - (b) Attraction flow distribution model:
 Dependent variable utility for commodity flows from production states
 Independent variables distance, percentage production level
- Step 6: Compute disaggregate Texas county truck flows
 - (a) Develop state-to-county and inter-county centroidal distance matrix.
 - (b) Compute external-internal flows by developing county attraction levels for each commodity group and disaggregating state-to-Texas flows to Texas county level.

- (c) Compute internal-external flows by developing county production levels for each commodity group and disaggregating Texas-to-State flows to Texas county level.
- (d) Compute internal-internal flows by disaggregating Texas intrastate flows to generate Texas county-to-county flows.

Step 1: Extract state-level commodity flows by truck mode for each commodity group to estimate production flow distribution and attraction flow distribution

The movement of commodity flows between states can be represented as production flows from an origin state and attraction flows to a destination state. Specifically, the annual truck flows (tonnage) from each production state to the 50 attraction states for each commodity group can be represented as follows:



Similarly, the annual truck flows (tonnage) attracted to each state from the fifty production states for commodity group k can be illustrated as follows:



The production/attraction truck flow information needed to calibrate the production flow distribution MNL model and the attraction flow distribution MNL model was extracted from the 1997 Commodity Flow Survey (CFS) and aggregated into nine commodity groups. The nine commodity groups are presented in Table 1.

Con	nmodity Group	Commodity Categories						
		Live animals and live fish						
1	A	Cereal grains						
1.	Agriculture	Other agricultural products						
		Animal feed and products of animal origin, n.e.c.						
		Meat, fish, seafood, and their preparations						
		Milled grain products and preparations, and bakery products						
2.	Food	Other prepared foodstuffs and fats and oils						
		Alcoholic Beverages						
		Tobacco Products						
		Monumental or building stone						
2	Duilding motorials	Nonmetallic mineral products						
5.	bunding materials	Base metal in primary or semi finished forms and in finished basic shapes						
		Articles of base metal						
		Natural sands						
		Gravel and crushed stone						
4.	Raw material	Nonmetallic minerals n.e.c.						
		Metallic ores and concentrates						
		Coal						
		Gasoline and aviation turbine fuel						
		Fuel oils						
		Coal and petroleum products, n.e.c.						
5.	Chemicals/Petroleum	Basic chemicals						
		Pharmaceutical products						
		Fertilizers						
		Chemical products and preparations, n.e.c.						
		Logs and other wood in the rough						
		Wood products						
6	Wood	Pulp, newsprint, paper, and paperboard						
0.	, , , , , , , , , , , , , , , , , , ,	Paper or paperboard articles						
		Printed products						
		Furniture, mattresses and mattress supports, lamps, lighting fittings, and						
7	Textiles	Plastics and rubber						
7.	rextiles	Textiles, leather, and articles of textiles or leather						
	Machinery	Machinery						
8.		Electronic and other electrical equipment, components and office equipment						
		Motorized and other vehicles (including parts)						
		Transportation equipment, n.e.c.						
		Precision instruments and apparatus						
		Miscellaneous manufactured products						
0	Missollarrana	Waste and scrap						
9.	winscentaneous	Mixed freight						

NOTE: Since detailed data on the movement of secondary and hazardous shipments by truck were not available from the CFS, these shipments have not been considered. Based on available literature, the percentage of inter-city and interstate truck flows of secondary and hazardous shipments is low compared to the flows of the major commodity groups considered. Therefore, the overall impact on the total truck flow estimates of not considering secondary and hazardous shipments is believed to be small.

Step 1 (a): Compile a table with the production flow distributions from each production state to all attraction states for each of the nine commodity groups

The required steps to generate the production flow table are as follows:

- Extract the required data (state origin, state destination, commodity value, commodity tonnage moved by trucks) for flows from **each production state** to **all attraction States** from the CFS and enter the data into an excel workbook (see Production Flow Distribution on the CD). In the 1997 CFS, these data variables could be extracted from "StatesTbl15(1997): Shipment characteristics by 2 digit commodity and mode of transportation". Also note that in 1997 the tonnage was in thousands of tons.
- Group the commodity information into the commodity groups shown in Table 1.
- Sum the value and tonnage for all commodities belonging to the same group to obtain the total flows for each commodity group from each production state to each attraction state. The excel screenshot displays the data for each of the commodities and the total tonnage and value of truck flows aggregated in the commodity groups from production state Alabama to attraction states Alabama, Arizona, Arkansas, California, and Colorado.

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7	Cereal grains	-	-	-	-	-	-	-	-	-	
8	Other agricultural products	423	-	-	-	-	-	-	-	-	-
9	Animal feed and products of animal origin,	984	5581	-	-	-	-	-	-	-	
10	Agriculture	141/	5590	0	0	0	0	0	0	0	
12	Meat, fish, seafood, and their preparations	629	406	-	-	190	87	127	90	-	
13	Milled grain products and preparations, an	206	172	-	-	-	-	-	-	-	
14	Other prepared foodstuffs and fats and oils	1483	2521	-	-	4	-	25	-	-	-
15	Alconolic beverages Tobacco products	629 486	4/5	-	-	-	-	-	-	-	
17	Food	3433	3600	0	0	194	87	152	90	0	
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19	Monumental or building stone	-	- 44000	-	-	-	-	-	-	-	-
20	Nonmetallic mineral products Base metal in primary or semifinished forn	/53 r 1448	11302	-	-	- 88	- 71	- 48	-	-	-
22	Articles of base metal	976	611	13	-	46	38		38	17	
23	Building Materials	3177	14521	13	0	134	109	106	38	17	
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27	Nonmetallic minerals n.e.c.	-	871	-	-	-	-	-	-	-	
28	Metallic ores and concentrates	-	-	-	-	-	-	-	-	-	-
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30	Raw Materials	536	33000	0	U	0	0	0	U	U	
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32	Gasoline and aviation turbine fuel	3330	12296	-	-	-	-	-	-	-	-
34	Coal and petroleum products, n.e.c.	240	1681	-	-	-	-	-	-	-	- 3
35	Basic chemicals	406	1096	-	-	-	65	16	-	-	
36	Pharmaceutical products	411	19	-	-	-	-	-	-	-	-
38	Fertilizers Chemical products and preparations in elo	91	212	-	-	- 87	- 21	-	-	-	
39	Chemicals/Petroleum	5654	19233	0	0	87	86	16	0	0	
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41	Logs and other wood in the rough	721	32047	-	-	- 10	- 110	-	- 7	-	-
42	Pulp, newsprint, paper, and paperboard	680	1312	-	-	42	46	- 108	134	-	
44	Paper or paperboard articles	429	546	-	-	-	-	8	1	-	-
45	Printed products	531	129	-	-	-	-	-	-	-	-
46	Furniture, mattresses and mattress suppo	270	30817	16	-	- 	5	49	11	35	·
48	TTO VI	3933	33017	10	0	02	101	100	133	35	
49	Plastics and rubber	755	297	-	-	-	-	127	53	-	
50	Textiles, leather, and articles of textiles or	3312	585	-	-	130	32	353	46	-	
51	Textiles	4067	882	0	0	130	32	480	99	0	
52 53	Machinery	1550	241	-		72	13	61		_	
54	Electronic and other electrical equipment :	1122	206	-	-	5	-	250	20	-	
55	Motorized and other vehicles (including pa	815	185	-	-	14	7	-	-	-	-
56	Transportation equipment, n.e.c.	4	-	-	-	-	-	19	1	-	
58	Miscellaneous manufactured products	24	- 884	-	-	- 89	- 45	- 20	- 5	-	
59	Machinery	5958	1516	0	0	180	65	350	26	0	
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61	Waste and scrap Mixed freight	191	1232	-	-	-	-	-	-	-	
63	Miscellaneous	1829	2231	0	0	0	0	0	0	0	
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NOTE: This data relates to the truck tonnage and value moved between **each production state** and **each attraction state**. In other words there will be a total of 50 worksheets (one for each production state). Each worksheet contains 100 columns that capture the tonnage and dollar flows by commodity to each attraction state from the specific production state.

Step 1 (b): Compile a table with the attraction flow distributions from all production states to each attraction state for each of the nine commodity groups

The procedure to generate the attraction flow distribution table for each commodity group is similar to that for the production flow distribution table. The required steps to generate the attraction flow table are as follows:

- Extract the required data (state destination, state origin, commodity value, commodity tonnage moved by trucks) for flows destined to **each attraction state** from **all production states** from the CFS and enter the data into an excel workbook (see Attraction Flow Distribution on the CD). In the 1997 CFS, these data variables could be extracted from "StatesTbl15(1997): Shipment characteristics by 2 digit commodity and mode of transportation". Also note that in 1997 the tonnage was in thousands of tons.
- Group the commodity information into the commodity groups shown in Table 1.
- Sum the value and tonnage for all commodities belonging to the same group to obtain the total flows for each commodity group destined for each attraction state from each production state. The excel screenshot displays the data for each of the commodities and the total tonnage and value of truck flows aggregated in the commodity groups destined for attraction state Alabama from production states Alabama, Arizona, Arkansas, California, Colorado, and Connecticut.

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27 Nonmetallic minerals n.e.c. 0 871 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <th< td=""><td>27 Nometalic minerals n.e.c. 0 871 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <td< td=""><td>26</td><td>Gravel and crushed stone</td><td>167</td><td>28756</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></td<></td></th<>	27 Nometalic minerals n.e.c. 0 871 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <td< td=""><td>26</td><td>Gravel and crushed stone</td><td>167</td><td>28756</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></td<>	26	Gravel and crushed stone	167	28756	0	0	0	0	0	0	0	0	0	
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NOTE: Although the procedure for generating the attraction flow distribution table is similar to that for the production flow distribution table, caution should be taken to ensure that the appropriate data is extracted. In other words, for the attraction flow distribution table the analyst needs to extract the commodity data destined for each state from all other states. In the case of the production flow distribution table, the analyst needs to extract the commodity data originating in each state destined for all other states.

Step 2: Calculate percentage productions and attractions for each state and commodity group

To calibrate the production flow distribution and attraction flow distribution MNL models, the percentage production and attraction levels of each State for each commodity group, respectively are needed. The required steps and the essence of the formulas for calculating the percentage productions in and attractions to each state are similar. Calculating the percentage productions in each state are thus subsequently used to illustrate the procedure. The same procedure needs to be followed to calculate the total attractions of each commodity group to each state.

Step 2 (a): Calculate the total productions of each commodity group in each state

The total production flows of each commodity group in each production state are obtained by adding the total flows from each production state to all attraction states by commodity group. Mathematically, the latter is expressed as follows:

$$P_i^k = \sum_{j=1}^{50} T_{ij}^k$$

Where T_{ij}^{k} = Annual tonnage of truck flows of commodity group k (k = 1 to 9) from production state i (i = 1 to 50) to attraction state j (j = 1 to 50).

The total production flows of each commodity group from each production state are calculated in the workbook titled Production Flow Distribution – Relative Utility Calcu on the CD from the production flow distribution table compiled (see Production Flow Distribution on the CD). Agricultural production flows from Alabama to all other states are used to illustrate the concept. First, the agricultural production flows from production state Alabama to each of the states are copied to/linked to the Production Flow Distribution – Relative Utility Calcu workbook (see screenshot on the opposite page).

The total attraction flows of each commodity group destined for each attraction state are obtained by adding the total flows to each attraction state from all production states by commodity group. Mathematically, the latter is expressed as follows:

$$A_{j}^{k} = \sum_{i=1}^{50} T_{ij}^{k}$$

Where T_{ij}^{k} = Annual tonnage of truck flows of commodity group k (k = 1 to 9) to attraction state j (j = 1 to 50) from production state i (i = 1 to 50).

The total attraction flows of each commodity group destined for each attraction state are calculated in the workbook titled Attraction Flow Distribution – Relative Utility Calcu on the CD from the attraction flow distribution table compiled in Step 1 (see Attraction Flow Distribution on the CD).
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	4 E	Air commodities	30300	144300	-	4	AREA:	Arizona	Tons(UUU)	0	U	
	6	Live enimele and live field	10	0	25	5	AREA:	Arkansas	Tons(UUU)	0	U	
	7	Coreal graine	10	9		5	AREA:	California	Tons(UUU)	0	0	
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	13	Milled grain products and preparations	2020	400		12	AREA.	Idobo	Tons(000)	40	0.007.344341	_
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	16	Tohacco products	486	26		16	ADEA	lowa	Tone(000)	0	0	
	17	Food	3433	3600		17	ADEA	Vancae	Tons(000)	0	0	_
	18		0.00			18	AREA.	Kantucky	Tons(000)	0	0	
	19	Monumental or huilding stone		2		19	AREA.	Louiciana	Tons(000)	0	0	
	20	Nonmetallic mineral products	753	11302		20	AREA.	Maine	Tons(000)	0	0	
	21	Base metal in primary or semifinished form	1448	2608	-	20	AREA	Maryland	Tons(000)	0	0	
	22	Articles of base metal	976	611		22	AREA	Massachusetts	Tons(000)	0	0	
	23	Building Materials	3177	14521		23	AREA	Michigan	Tons(000)	0	0	
	24					24	AREA	Minnesota	Tons(000)	30	0.00489636	
	25	Natural sands	-	_	-	25	AREA	Mississippi	Tons(000)	0	0	
	26	Gravel and crushed stone	167	28756	-	26	AREA	Missouri	Tons(000)	4	0.000652848	
	27	Nonmetallic minerals n.e.c.	-	871	-	27	AREA	Montana	Tons(000)	0	0	
	28	Metallic ores and concentrates	-	-	-	28	AREA:	Nebraska	Tons(000)	0	0	
	29	Coal	369	10241	4	29	AREA:	Nevada	Tons(000)	0	0	
	30	Raw Materials	536	39868		30	AREA:	New Hampshire	Tons(000)	0	0	
	31					31	AREA:	New Jersey	Tons(000)	0	0	
	32	Gasoline and aviation turbine fuel	3330	12296	- 🗸	32	AREA:	New Mexico	Tons(000)	0	0	
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Note: Both the Step 2 and 3 calculations are done in the Production Flow Distribution – Relative Utility Calcu workbook.

Second, the total production flows of agricultural commodities from all production states are calculated by summing the agricultural production flows from each of the states listed in the Production Flow Distribution – Relative Utility Calcu workbook (see screenshot on the opposite page).

3	Microsoft Excel - Step 3 Pro	duction Flo	w Distributio	n - Relative Utility	/ Calcu. xls				
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	A	B	C	D	E	F	G	H	
1	Origin State: Alabama	Tana (000)	Agriculture	Fractional Flows	Revised Fractional Flows	Relative Utility	Food	Fractional Flows	Revised Fraction
4	AREA: Alabama	Tons(000)	0	0.912355149	0.00001	11.420761	0000	0.623916011	0.0230200
4	AREA: Arizona	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
5	AREA: Arkansas	Tons(000)	0 0	<u> </u>	0.00001	-11.420761	87	0.01507799	0.0150779
6	AREA: California	Tons(000)	0	0	0.00001	-11.420761	90	0.01559792	0.0155979
7	AREA: Colorado	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
8	AREA: Connecticut	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
9	AREA: Delaware	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
10	AREA: District of Columbia	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
11	AREA: Florida	Tons(UUU)	109	0.017790109	0.017790109	-3.936948162	564	0.097746967	0.0977469
12	AREA: Georgia	Tons(000)	40	0.007.344541	0.00001	-4.021033004 11.400761	411	0.071230503	0.0712305
14	AREA: Illinois	Tons(000)	24	0.003917088	0.00001	-5 450242214	92	0.015944541	0.00001
15	AREA: Indiana	Tons(000)	0	0.0000011000	0.00001	-11 420761	0	0.013044041	0.0100440
16	AREA: Iowa	Tons(000)	0	0	0.00001	-11.420761	24	0.004159445	0.0041594
17	AREA: Kansas	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
18	AREA: Kentucky	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
19	AREA: Louisiana	Tons(000)	0	0	0.00001	-11.420761	49	0.008492201	0.0084922
20	AREA: Maine	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
21	AREA: Maryland	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
22	AREA: Massachusetts	Tons(UUU)	<u> </u>	<u> </u>	0.00001	-11.420/61	<u> </u>	0.040040544	0.00001
23	AREA: Michigan	Tons(000)	20	0.00400000	0.00001	-11.420761 5 00000000	0	0.010910544	0.0109105
24	AREA: Minnesota	Tons(000)	0	0.00403030	0.00405030	-11 /20761	211	0.036568458	0.0365684
26	AREA: Missouri	Tons(000)	4	0.000652848	0.000652848	-7 242001683	40	0.006932409	0.0069324
27	AREA: Montana	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
28	AREA: Nebraska	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
29	AREA: Nevada	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
30	AREA: New Hampshire	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
31	AREA: New Jersey	Tons(000)	0	0	0.00001	-11.420761	15	0.002599653	0.0025996
32	AREA: New Mexico	Tons(UUU)	0	<u> </u>	0.00001	-11.420761	0	0.000770000	0.00001
33	AREA: New York	Tons(UUU)	40	0.007007290	0.00001	-11.420/b1	39	0.009219901	0.00921990
34	AREA: North Carolina	Tons(000)	49	0.007997389	0.007997389	-4.736475746	48	0.008318891	0.0083188
35	AREA: North Dakota	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
36	AREA: Ohio	Tons(000)	0	0	0.00001	-11.420761	55	0.009532062	0.0095320
37	AREA: Oklahoma	Tons(000)	10	0.00163212	0.00163212	-6.325710951	6	0.001039861	0.0010398
38	AREA: Oregon	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
39	AREA: Pennsylvania	Tons(UUD)	0	0	0.00001	-11.420761	31	0.005372617	0.0053726
40	AREA: Rhode Island	Tons(UUU)	0	0	0.00001	-11.420761	57	0 00979692	
41	AREA: South Dakota	Tons(000)	0	ρ	0.00001	-11.420761	- 57 П	0.009070003	0.0090706
43	AREA: Tennessee	Tons(000)	222	0.036233067	0.036233067	-3.225618662	191	0.033102253	0.0331022
44	AREA: Texas	Tons(000)	44	0.007181329	0.007181329	-4.84410641	90	0.01559792	0.0155979
45	AREA: Utah	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
46	AREA: Vermont	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
47	AREA: Virginia	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
48	AREA: Washington	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
49	AREA: West Virginia	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
50	AREA: Wisconsin	Tons(UUU)	0	0	0.00001	-11.420761	/	0.001213172	0.0012131
51	AREA: Wyoming	rons(UUU)	0	0	0.00001	-11.420761	0	0	0.00001
53			6127	1	1	-502.6402759	5770	1	1
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Note: The values in the "revised fractional flows" and the "relative utility" columns are calculated in Step 3.

Step 2 (b): Calculate the fractional production and attraction flows for each state and commodity group

The fractional production flows of each commodity group destined for state j from production state i are calculated as follows:

$$FP_{ij}^{k} = \frac{T_{ij}^{k}}{P_{i}^{k}}$$

Where,

 T_{ij}^{k} = Annual tonnage of truck flows of commodity group k (k = 1 to 9) from production state i (i = 1 to 50) to attraction state j (j = 1 to 50)

 P_i^k = Total productions of commodity group k in production state i

The calculation is illustrated on the opposite page.

The fractional attraction flows of each commodity group attracted to state *j* from production state *i* are calculated as follows:

$$FA_{ij}^k = \frac{T_{ij}^k}{A_i^k}$$

Where,

 T_{ij}^{k} = Annual tonnage of truck flows of commodity group *k* (*k* = 1 to 9) to attraction state *j* (*j* = 1 to 50) from production state *i* (*i* = 1 to 50).

 A_{i}^{k} = Total attractions of commodity group k to attraction state j

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1	A Origin State: Alahama			Eractional Flows	E Revised Fractional Flows	Relative Iltility	Eaad	Eractional Flows	Revised Eraction
2	AREA: Alahama	Tons(000)	• 5590	8 912355149	0.911955149	n n	3600	0.623916811	0.6236268
3	ABEA: Alaska	Tons(000)	0	0		-11.420761	0	0	0.00001
4	AREA: Arizona	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
5	AREA: Arkansas	Tons(000)	0	0	0.00001	-11.420761	87	0.01507799	0.0150779
6	AREA: California	Tons(000)	0	0	0.00001	-11.420761	90	0.01559792	0.0155979
7	AREA: Colorado	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
8	AREA: Connecticut	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
9	AREA: Delaware	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
10	AREA: District of Columbia	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
11	AREA: Florida	Tons(000)	109	0.017790109	0.017790109	-3.936948162	564	0.097746967	0.0977469
12	AREA: Georgia	Tons(UUU)	45	0.007344541	0.00004	-4.821633554	411	0.071230503	0.07123050
13	AREA: Idano	Tons(000)	24	0.002017099	0.00001	-11.420761	0	0.015044541	0.00001
14	AREA: Indiana	Tons(000)	24	0.003917000	0.00001	-5.450242214	92	0.010944041	0.01094454
15	AREA: Inuiaria	Tons(000)	0	0	0.00001	-11.420761	24	0.004159445	0.00001
17	AREA: Kansas	Tons(000)	0	0	0.00001	-11.420761	24	0.004103440	0.00413344
18	AREA: Kentucky	Tons(000)	0	0	0.00001	-11 420761	n	0	0.00001
19	AREA: Louisiana	Tons(000)	n n	n n	0.00001	-11 420761	49	0.008492201	0.00849220
20	AREA: Maine	Tons(000)	ō	0	0.00001	-11.420761	0	0	0.00001
21	AREA: Marvland	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
22	AREA: Massachusetts	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
23	AREA: Michigan	Tons(000)	0	0	0.00001	-11.420761	63	0.010918544	0.0109185
24	AREA: Minnesota	Tons(000)	30	0.00489636	0.00489636	-5.227098663	0	0	0.00001
25	AREA: Mississippi	Tons(000)	0	0	0.00001	-11.420761	211	0.036568458	0.0365684
26	AREA: Missouri	Tons(000)	4	0.000652848	0.000652848	-7.242001683	40	0.006932409	0.0069324(
27	AREA: Montana	Tons(000)		0	0.00001	-11.420761	0	0	0.00001
28	AREA: Nebraska	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
29	AREA: Nevada	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
30	AREA: New Hampshire	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
31	AREA: New Jersey	Tons(000)	0		0.00001	-11.420761	15	0.002599653	0.0025996
32	AREA: New Mexico	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
33	AREA: New York	Tons(000)	0	0	0.00001	-11.420761	39	0.006759099	0.0067590
34	AREA: North Carolina	Tons(000)	49	0.007997389	0.007997389	-4.736475746	48	0.008318891	0.0083188
35	AREA: North Dakota	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
36	AREA: Ohio	Tons(000)	0	0	0.00001	-11.420761	55	0.009532062	0.0095320(
37	AREA: Oklahoma	Tons(000)	10	0.00163212	0.00163212	-6.325710951	6	0.001039861	0.0010398
38	AREA: Oregon	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
39	AREA: Pennsylvania	Ions(000)		0	0.00001	-11.420761	31	0.005372617	0.0053726
40	AREA: Rhode Island	Tons(UUU)	<u> </u>	U	0.00001	-11.420/61	0	0.000070000	0.00001
41	AREA: South Carolina	Tons(UUU)		0	0.00001	-11.420761	5/	0.009878683	0.00987868
42	AREA: South Dakota	Tons(000)		0.00000007	0.00001	-11.420761	101	0.000100050	0.00001
43	AREA: Texas	Tons(000)	422	0.036233067	0.007191200	-3.220010002	191	0.033102253	0.0331022
44	AREA: Texas	Tons(000)		0.007101325	0.007101329	11 420761		0.01009792	0.0100978
40	AREA: Vermont	Tone(000)	0	0	0.00001	-11.420761	0	0	0.00001
40	AREA: Virginia	Tons(000)	0	0	0.00001	-11.420701	0	0	0.00001
48	AREA: Washington	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
49	AREA: West Virginia	Tons(000)	0	0	0.00001	-11,420761	0	0	0.00001
50	AREA: Wisconsin	Tons(000)	0	0	0.00001	-11.420761	7	0.001213172	0.0012131
51	AREA: Wyoming	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001
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Step 3: Compute Utility Values for Production Flow Distribution and Attraction Flow Distribution

In calibrating the MNL production flow distribution and attraction flow distribution models, utility values have to be calculated for each because the factors impacting the flows differ in these two cases. The process for computing the utility values is, however, similar.

Step 3(a): Compute Utility Values for Production Flow Distribution Model

In the production flow distribution model, the utility values represent the propensity for flows from production state i to each of the attraction states j. From the definition of the MNL model, the fraction of the total production flows of commodity group k from production state i to state j among n alternative states can be expressed as follows:

$$FP_{ij}^{k} = \frac{e^{V_{ij}^{k}}}{\sum_{j=1}^{n} e^{V_{ij}^{k}}}$$

Where,

 V_{ii}^{k} = Utility value for flows from state *i* to state *j* for commodity group *k*

During Step 3(a) the utility values for production flows from each production state to each attraction state for each commodity group is calculated. Agricultural production flows from Alabama to all other states are used to illustrate the computation of the utility values.

The steps involved in computing the utility values are:

1. Examination of the fractional production flows calculated in Step 2(b) (see Column D in the Excel workbook Production Flow Distribution – Relative Utility Calcu on the CD) reveals that in a number of cases the production flows from Alabama to some of the attraction states are zero. If the production flows are zero, the utility value will be negative infinity and therefore undetermined (given the mathematical equation of the logit model). The fractional production flows therefore needs to be adjusted so that utility values can be computed for all flows from each production state to each attraction state.

The utility values for zero flows can be approximated through a minor adjustment to the fractional flows. The adjustment involves replacing the zeros with a very small value (0.00001) to ensure that the computed utilities have a high negative value. Also, since the total fractional production flows have to equal 1, the added adjusted flows (= 0.00001 * number of cells with zero flows) must be deducted from the flows in another cell(s) to ensure that the total fractional production flows sum to 1. For simplicity, the added adjusted flows were subtracted from the cell containing the highest fractional flows.

- 2. Once the revised fractional flows from Alabama to each attraction state are calculated, the utilities can be computed using the MNL equation on page x.
 - a. The utility values for production flows from Alabama to each attraction state are the unknowns that need to be calculated. Thus, there are a total of 50 unknowns. Applying the MNL equation to production flows from Alabama to each attraction state results in 49 independent equations.² Thus, there are 49 independent equations and 50 unknowns to solve. This is addressed by assigning the utility value for flows from Alabama to an arbitrary state *s* as zero and computing the utilities for production flows to the remaining states relative to the utility for flows to state *s*. The latter is referred to as the base utility since the utility for flows from Alabama to all the other attraction states are relative to the utility for flows from Alabama to state *s*. Given the base utility value, there are 49 utility unknowns to be determined from 49 independent equations.
 - b. In this example, the utility for agricultural production flows from Alabama to Alabama is assumed to be zero. The next step is to substitute the zero value and the revised fractional agricultural production flows in the MNL equation as follows:

$$0.911955149 = \frac{e^0}{\sum_{j=1}^{49} e^{V_{Al,j}^{agri}}} = \frac{1}{\sum_{j=1}^{49} e^{V_{Al,j}^{agri}}}$$

Because it is a fraction-based equation the last equation is redundant.

2

$$\Rightarrow \sum_{j=1}^{49} e^{V_{AI,j}^{agri}} = \frac{1}{0.91195514.9}$$
$$\Rightarrow \sum_{j=1}^{49} e^{V_{AI,j}^{agri}} = 1.09654515$$

Given $\sum_{j=1}^{49} e^{V_{Al,j}^{agri}} = 1.09654515$, the relative utilities for flows from Alabama to

the other attraction states can be calculated. These utilities are referred to as relative utilities, because the values are computed relative to the base utility (i.e., utility for agricultural production flows from Alabama to Alabama). For example, the relative utility for the fractional agricultural production flows from Alabama to Arizona can be computed as follows:

$$0.00001 = \frac{e^{V_{Al,Ar}^{agri}}}{\sum_{j=1}^{49} e^{V_{Al,j}^{agri}}}$$
$$0.00001 = \frac{e^{V_{Al,Ar}^{agri}}}{1.096545155}$$
$$e^{V_{Al,Ar}^{agri}} = 1.096545155E - 05$$

Applying the natural logarithm on both sides provide:

•
$$V_{Al,Ar}^{agri} = -11.420761$$

Thus, the relative utility for the fractional flows of agricultural commodities from Alabama to Arizona relative to the fractional agricultural production flows from Alabama to Alabama is equal to -11.42076. The relative utilities for the fractional commodity group production flows from Alabama to all the remaining attraction states are computed similarly (see screenshot on opposite page).

(Calc	ulation of 1	Revise	d Fract	tional Flov	vs					
I	n col	lumn D, the	ere are	40 cells	with zero	flows.					
I	n co	olumn E, t	hese z	zeros ar	e replaced	l with					
0	0.000	01. Thus,	0.000	40 need	s to be de	ducted		Ca	alculation o	of Relative I	Util
t	o en	sure that t	he tot	al fract	ional prod	uction			V	alues	
f	lows	sum to 1.						T 1.	. C		1
F	For si	implicity, 0	.0004	0 was d	educted fro	om the			e formula	used in Ex	
с	ell w	vith the high	hest f	ractiona	l flows (i.e	e., cell			unate the	relative $N(E_2/(E_2))$	uu
E	E2).		,		× ×	,		vai	$7 \qquad \checkmark$	N(E3/φEφ2).	·
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_	F3		N(E3/\$E\$2)	-			_	1/			
1	Origin S	A State: Alabama	В	C Agriculture	Fractional Flows	E Vevised Fractional Flow	⊦ ws <mark>RelativeUtility</mark>	Food	H Fractional Flows	Revised Fraction	
2	AREA: A	Alabama	Tons(000)	5590	0.912355149	0.911955149	0	3600	0.623916811	0.6236268	
3	AREA: /	Alaska Arizona	Tons(000)	U 0	0		-11.420761	0	0	0.00001	
5	AREA: A	Arkansas	Tons(000)	Ŭ	Ū Ū	0.00001	-11.420761	87	0.01507799	0.0150779	
6	AREA: (California	Tons(000)	0	0	0.00001	-11.420761	90	0.01559792	0.0155979	
7	AREA: (Colorado	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
8	AREA: (Connecticut Deleviere	Tons(UUU)	U	0	0.00001	-11.420761	U	0	0.00001	
9	AREA: I	Delaware District of Columbia	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
11	AREA: F	Florida	Tons(000)	109	0.017790109	0.017790109	-3.936948162	564	0.097746967	0.0977469	
12	AREA: (Georgia	Tons(000)	45	0.007344541	0.007344541	-4.821633554	411	0.071230503	0.0712305(
13	AREA: I	Idaho	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
14	AREA: I	llinois	Tons(000)	24	0.003917088	0.003917088	-5.450242214	92	0.015944541	0.0159445	
15	AREA: I	Indiana	Tons(UUU)	0	0	0.00001	-11.420761	24	0.004159445	0.00001	
17	AREA: I	lowa Kansas	Tons(000)	0	0	0.00001	-11.420761	4 	0.004155445	0.0041594	
18	AREA: I	Kentucky	Tons(000)	Ō	Ő	0.00001	-11.420761	Ū	Ő	0.00001	
19	AREA: l	Louisiana	Tons(000)	0	0	0.00001	-11.420761	49	0.008492201	0.0084922(
20	AREA: N	Maine	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
21	AREA: I	Maryland Massachusette	Tons(UUU)	0	0	0.00001	-11.420761	0	0	0.00001	
23	AREA: 1	Michigan	Tons(000)	0	0	0.00001	-11.420761	63	0.010918544	0.0109185	
24	AREA: N	Minnesota	Tons(000)	30	0.00489636	0.00489636	-5.227098663	0	0	0.00001	
25	AREA: N	Mississippi	Tons(000)	0	0	0.00001	-11.420761	211	0.036568458	0.0365684	
26	AREA: N	Missouri	Tons(000)	4	0.000652848	0.000652848	-7.242001683	40	0.006932409	0.0069324(
27	AREA: I	Nontana	Tons(UUU)	0	0	0.00001	-11.420761	0	0	0.00001	
20	AREA: I	Nevada	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
30	AREA: I	New Hampshire	Tons(000)	0	0	0.00001	-11.420761	Ū	0	0.00001	
31	AREA: 1	New Jersey	Tons(000)	0	0	0.00001	-11.420761	15	0.002599653	0.0025996	
32	AREA: N	New Mexico	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
33	AREA: 1	New York	Tons(000)	0	0	0.00001	-11.420761	39	0.006759099	0.0067590	
34	AREA: 1	North Carolina	Tons(000)	49	0.007997389	0.007997389	-4.736475746	48	0.008318891	0.0083188	
35	AREA: Ì	North Dakota	Tons(UUU)		U	0.00001	-11.420761	U EE	0.000500000	0.00001	
37	AREA: (Oklahoma	Tons(000)	10	0.00163212	0.00163212	-6.325710951		0.001039861	0.0010398	
38	AREA: (Oregon	Tons(000)	0	0	0.00001	-11.420761	ō	0	0.00001	
39	AREA: F	Pennsylvania	Tons(000)	0	0	0.00001	-11.420761	31	0.005372617	0.0053726	
40	AREA: P	Rhode Island	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
41	AREA: S	South Carolina	Tons(000)	0	0	0.00001	-11.420761	- 57 - 0	0.009878683	0.0098786	
43	AREA: 1	Tennessee	Tons(000)	222	0.036233067	0.036233067	-3.225618662	191	0.033102253	0.03310224	
44	AREA: 1	Texas	Tons(000)	44	0.007181329	0.007181329	-4.84410641	90	0.01559792	0.0155979	
45	AREA: I	Utah	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001 🚪	
46	AREA: \	Vermont	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
47	AREA: \	√irginia Mashira	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
48	AREA: \	Washington	Tons(000)	0	0	0.00001	-11.420761	0	0	0.00001	
49 50	AREA: \	vvest virginia Wieconsin	Tons(UUU)	0	U 0	0.00001	-11.420761	7	U 0.00101212170	0.00001	
51	AREA: \	Wvomina	Tons(000)	0	n	0,00001	-11,420761		0.001213172	0.00121317	
52						0.0001	11.420101		0	0.00001	
53				6127	11	1	-502.6402759	5770	1	1	
54											

Step 3(b): Compute Utility Values for Attraction Flow Distribution Model

In the attraction flow distribution model, the utility values represent the propensity for flows to attraction state j from each of the production states i. From the definition of the MNL model, the fraction of the total attraction flows of commodity group k to attraction state j from production state i among n alternative production states can be expressed as follows:

$$FP_{ji}^{k} = \frac{e^{V_{ji}^{k}}}{\sum_{i=1}^{n} e^{V_{ji}^{k}}}$$

Where,

 V_{ii}^{k} = Utility value for flows to state *j* from state *i* for commodity group *k*

During Step 3(b) the utility values for attraction flows to each attraction state from each production state for each commodity group is calculated. Agricultural attraction flows to Alabama from all other states are used to illustrate the computation of the utility values.

The steps required to compute the utility values are:

1. Examination of the fractional attraction flows calculated in Step 2(b) (See Column D in the Excel workbook Attraction Flow Distribution – Relative Utility Calcu on the CD) reveals that in a number of cases the agricultural attraction flows to Alabama from many of the production states are zero. If the attraction flows are zero, the utility value will be negative infinity and therefore undetermined (given the mathematical equation of the logit model). The fractional attraction flows therefore needs to be adjusted so the utility values can be computed for all flows to each attraction state from each production state.

The utility values for zero flows can be approximated through a minor adjustment to the fractional flows. The adjustment involves replacing the zeros with a very small value (0.00001) to ensure that the computed utilities have a high negative value. Also, since the total fractional attraction flows to Alabama from all the production states have to equal 1, the added adjusted flows (= 0.00001 * Number of cells with zero flows) must be deducted from the flows in another cell(s) to ensure that the total fractional attraction flows sum to 1. For simplicity, the added adjusted flows were subtracted from the cell containing the highest fractional flows.

- 2. Once the revised fractional flows to Alabama from each production state are calculated, the utilities can be computed using the MNL equation on page x.
 - a. The utility values for attraction flows to Alabama from each production state are the unknowns that need to be calculated. Thus, there are a total of 50 unknowns. Applying the MNL equation to attraction flows to Alabama from each production state results in 49 independent equations³. Thus, there are 49 independent equations and 50 unknowns to solve. This is addressed by assigning the utility value for flows to Alabama from an arbitrary production state *s* as zero and computing the utilities for attraction flows from the remaining states relative to the utility for flows to Alabama from all the other production states are relative to the utility for flows to Alabama from state *s*. Given the base utility value, there are 49 utility unknowns to be determined from 49 independent equations.
 - b. In this example, the utility for agricultural attraction flows to Alabama from Alabama is assumed to be zero. The next step is to substitute the zero value and the revised fractional agricultural attraction flows in the MNL equation as follows:

$$0.89957 = \frac{e^{0}}{\sum_{i=1}^{49} e^{V_{Al,i}^{agri}}} = \frac{1}{\sum_{i=1}^{49} e^{V_{Al,i}^{agri}}}$$

3

Because it is a fraction-based equation the last equation is redundant.

$$\sum_{i=1}^{49} e^{V_{Al,i}^{agri}} = 1.111642229$$

Given $\sum_{i=1}^{49} e^{V_{Al,i}^{agri}} = 1.111642229$, the relative utilities for flows to Alabama from

the other production states can be calculated. For example, the relative utility for the fractional agricultural attraction flows to Alabama from Arizona can be computed as follows:

$$0.00001 = \frac{e^{V_{Al,Ar}^{agri}}}{\sum_{i=1}^{49} e^{V_{Al,i}^{agri}}}$$
$$0.00001 = \frac{e^{V_{Al,Ar}^{agri}}}{1.111642229}$$
$$e^{V_{Al,Ar}^{agri}} = 1.111642229 E - 05$$

Applying the natural logarithm on both sides provide:

$$V_{Al,Ar}^{agri} = -11.40708706$$

c. Thus, the relative utility for the fractional flows of agricultural commodities to Alabama from Arizona relative to the fractional agricultural attraction flows to Alabama from Alabama is equal to -11.40708706. The relative utilities for the fractional commodity group attraction flows to Alabama from all the remaining production states are computed similarly (see screenshot on opposite page).

	Calculation of	Revis	ed Fra	ctional Flo	ows							
a.	In column D, th	ere ar	e 40 cel	ls with zer	o flows.							
c.	In column E, 0.00001. Thus	these , 0.000	zeros 040 nee	are replace eds to be d	ed with educted			С	alcula	tion o	f Relativ	e Utility
	flows sum to 1.	uie i	.0tai 11	actional at	laction			Th	fam.	Va	alues	Encol to
d.	For simplicity, cell with the hi	0.0004 ghest	40 was fraction	deducted f al flows (i	rom the i.e., cell				le form lculate	the	relative	e utility
	E2).							, vu	7			27.
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1	Destination State: Alabama AREA: Alabama	Tons/000	Agriculture 7728 75	Fractional Flows	R vised Fraction	onal Flows 7	Relative Utility	Food 3600	ctional Flo	Interpretation Fractions 0.568101	relative utili	
3	AREA: Alaska	Tons(000)	0	0.0339730	0.0000	11	-11.40708706	0	0.000001	0.00001	-10.9474698	
4	AREA: Arizona	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
5	AREA: Arkansas	Tons(000)	43	0.005007132	0.0050	11	-5.191053525	24	0.003789	0.003789	-5.01017773	
5	AREA: California	Tons(000)	30	0.003493348	0.0034	.9	-5.551056259	13	0.002052	0.002052	-5.62328220	
8	AREA: Connecticut	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
9	AREA: Delaware	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
10	AREA: District of Columbia	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
11	AREA: Florida	Tons(UUU)	223	0.025967221	0.0255	/	-3.545081869	168	0.144616	0.026524	-3.06426758	1
13	AREA: Idaho	Tons(000)	0	0.035355261	0.0000	11	-11.40708706	0	0.144010	0.00001	-10.9474698	
14	AREA: Illinois	Tons(000)	0	0	0.0000	11	-11.40708706	96	0.015156	0.015156	-3.62388337	
15	AREA: Indiana	Tons(000)	17	0.001979564	0.0019	8	-6.119040297	38	0.005999	0.005999	-4.55064540	
16	AREA: Iowa	Tons(000)	0	0	0.0000	11	-11.40708706	43	0.006789	0.006789	-4.42703144	
17	AREA: Kansas AREA: Kentucky	Tons(UUU)	36	0 004192018	0.0000	9	-11.40708706	40	0.006315	0.006315	-4.4993521	
19	AREA: Louisiana	Tons(000)	0	0	0.0000	1	-11.40708706	20	0.003158	0.003158	-5.19249929	
20	AREA: Maine	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
21	AREA: Maryland	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
22	AREA: Massachusetts AREA: Michigan	Tons(UUU)	0	0	0.0000	1	-11.40708706	21	0.003315	0.00001	-10.9474698	
24	AREA: Minnesota	Tons(000)	0	0	0.0000	11	-11.40708706	0	0.000010	0.00001	-10.9474698	
25	AREA: Mississippi	Tons(000)	15	0.001746674	0.0017	5	-6.244203439	121	0.019103	0.019103	-3.39244101	
26	AREA: Missouri	Tons(000)	0	0	0.0000	11	-11.40708706	10	0.001579	0.001579	-5.88564647	
27	AREA: Montana AREA: Nebraska	Tons(UUU)	0	0	0.0000	1	-11.40708706	0 39	0.006157	0.00001	-10.9474698	
29	AREA: Nevada	Tons(000)	Ő	0	0.0000	11	-11.40708706	0	0.000101	0.00001	-10.9474698	
30	AREA: New Hampshire	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
31	AREA: New Jersey	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
32	AREA: New Mexico	Tons(UUU)	U	0	0.0000	1	-11.40/08/06	U •••	U	0.00001	-10.9474698	
32	AREA: New Mexico	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
33	AREA: New York	Tons(000)	0	0	0.0000	11	-11.40708706	16	0.002526	0.002526	-5.41564284	
34	AREA: North Carolina	Tons(000)	0	0	0.0000	11	-11.40708706	46	0.007262	0.007262	-4.35959016	
35	AREA: North Dakota	Tons(000) Tons(000)	0	0	0.0000	1	-11.40708706	25	0	0.00001	-10.9474698	
30	AREA: Oklahoma	Tons(000)	0	0	0.0000	1	-11.40708706	 6	0.000947	0.000947	-6.39647209	
38	AREA: Oregon	Tons(000)	Ő	Ō	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
39	AREA: Pennsylvania	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
40	AREA: Rhode Island	Tons(000)	0	0	0.0000	11	-11.40708706	0	0 000047	0.00001	-10.9474698	
41	AREA: South Carolina AREA: South Dakota	Tons(000)	ρ	ρ	0.0000	1	-11.40708706	44 N	0.006947	0.006947	-4.4040419; -10.9474698	
43	AREA: Tennessee	Tons(000)	170	0.019795639	0.0198	0	-3.816455204	768	0.12125	0.12125	-1.54444183	
44	AREA: Texas	Tons(000)	21	0.002445344	0.0024	5	-5.907731203	202	0.031891	0.031891	-2.87996386	
45	AREA: Utah	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
46	AREA: Vermont	Tons(UUU)	U	U	0.0000	1	-11.40708706	10	0.003	0.00001	-10.9474698	
47	AREA: Washington	Tons(000)	0	0	0.0000	1	-11.40708706	0	0.000	0.00001	-10.9474698	
49	AREA: West Virginia	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
50	AREA: Wisconsin	Tons(000)	0	0	0.0000	11	-11.40708706	29	0.004578	0.004578	-4.82093573	
51	AREA: Wyoming	Tons(000)	0	0	0.0000	11	-11.40708706	0	0	0.00001	-10.9474698	
52			8587.75	1	0.99999	62	-501.2620647	6334	1	1	-385,830299	
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Step 4: Develop State-to-State Centroidal Distance Matrix

State-to-state centroidal distances were calculated using the TransCAD GIS software as the shortest path distance along the highway network between state centroids. The procedure for calculating the inter-state centroidal distances is as follows:

- Create a TransCAD map with the U.S. state and highway layers.
- Connect the state centroids to the highway layer using *Centroid Connectors*⁴ in the *Planning/Planning Utilities* feature of TransCAD.
- Create a highway network that includes the newly added nodes representing the state centroids. The new highway network is created by selecting the highway nodes representing state centroids and designating these nodes as centroids in the *Network Settings* feature of TransCAD.
- Compute the inter-state centroidal distances by calculating the shortest path distance along the highway network between state centroids. The output from TransCAD is a shortest path inter-state centroidal distance matrix.

In the absence of significant changes to the inter-state highway system, these centroidal distances (see State to State Centroidal Distances on the CD) can be used in future model calibrations.

⁴ The highway network needs to be linked to the state centroids, because state centroids do not represent highway nodes.

Step 5: Conduct Linear Regression Analysis

Production Flow Distribution

For the production flow distribution model, utility equations need to be developed for commodity flows from production state i to the attraction states j as a function of a set of independent variables that impact the production flow distribution of commodities. The two independent variables considered in developing the utility equations are:

- a) distance, which represents an impedance measure for commodity flows between states calculated in Step 4 (see the workbook State to State Centroidal Distances on the CD), and
- b) the fractional attraction level of the attraction states calculated in the workbook Attraction Flow Distribution on the CD. The fractional attraction level of the attraction states is determined by calculating the flows of commodity group k destined for the attraction state j as a percentage of the total commodity k flows destined for all attraction states (see screenshot on opposite page).

In other words, the distribution of commodity flows from production state i to the attraction states j can be estimated considering the inter-state centroidal distances and the percentage of the commodity flows destined for the attraction state j of the total commodity flows destined for all attraction states (i.e., fractional attraction level of attraction states).

Fractional Attraction Level of Destination States

Total flows destined for Alabama as a percentage of the total agricultural flows destined for all attractions states (i.e., C3/\$C\$53*100).

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3 AREA: Alabama	8587.75	2.048034094	6334	1.23591932	19053	1.896334132	41210	2.119833068	23595	2.220271232	44035	6.754538817	2453	2.272958924	2786
4 AREA: Arizona	273	0.065105913	8719	1.70129153	21916	2.181286876	9305	0.478647093	14209	1.337055899	3062	0.469680887	963	0.892319382	1579
5 AREA: Arkansas	11079	2.642155363	4319	0.842743218	8422	0.838236816	12148	0.624890369	16046	1.509916176	15957	2.447647914	1100	1.019264091	1504
AREA: California	28691	6.842321467	66283	12.93344494	93100	9.266189456	191613	9.856529328 0.9200E4142	131419	12.36642615	54681	8.38/531215	9015	8.35333253	15226
AREA: Connecticut	134	0.031956749	3689	0.71981471	4999	0.497547595	9584	0.350834142	9253	0.840000135	2554	0.39175865	534	0.631017133	406
AREA: Delaware	642	0.153106214	986	0.192392872	950	0.094552954	4251	0.218670477	469	0.044132537	294	0.045096728	48	0.044476979	160
0 AREA: District of Columbia	0	0	117	0.02282958	1462	0.145512019	574	0.02952643	588	0.055330345	640	0.098169748	17	0.015752263	28
1 AREA: Florida	7731	1.843713613	26601	5.190509919	57725	5.745336051	78912	4.05921541	65568	6.169898034	34416	5.279078186	3571	3.308901882	8333
2 AREA: Georgia	10131	2.416073291	18037	3.519462705	34039	3.387882093	110674	5.693045497	23506	2.211896401	12046	1.847738721	9059	8.394103094	8236
AREA: Idaho	3122 EDCAE	0.744544548	1382	0.26966222	5046	0.502225478	9101	0.468153379	2964	0.278910105 4 0000E0E0E	10212	0.279937171	197	0.182540933	256
AREA: Infrida	11185	2.667434593	12757	2 489204721	23164	3 323088439	84129	4 327576709	461/2	4.030308080	9492	1.455980072	2251	2.085784972	8340
AREA: Iowa	47768	11.39186546	10577	2.063833067	18228	1.814222357	54571	2.807119882	16028	1.50822239	3067	0.470447838	960	0.889539571	2212
7 AREA: Kansas	23065	5.500614989	6760	1.319042406	8653	0.861228113	12872	0.662132765	8421	0.79240958	3170	0.486247032	874	0.809851651	1464
AREA: Kentucky	3518	0.838983895	7406	1.445092909	20884	2.078572509	93607	4.815122882	16588	1.560917957	6501	0.997189891	1805	1.672519713	4622
AREA: Louisiana	991	0.23633685	6745	1.316115537	3793	0.377515109	17593	0.904979936	15728	1.479992623	31372	4.812158323	897	0.831163536	1491
D AREA: Maine	80	0.019078656	854	0.166636422	1016	0.101121896	991	0.050976816	6082	0.572311491	6093	0.934606677	198	0.183467536	179
AREA: Maryland	2336	0.55/096/53	/524	1.46811/613	1/961	1.787648	26813	1.379254648	12466	1.173040948	7256	1.112999515	1247	1.1554/4838	1922
AREA: Michigan	8571	2 0440395	18287	3 568243859	65232	6 492503444	60691	3 121931296	50688	4 769701555	11916	1.827797991	4501	4 170643341	2625
4 ABEA: Minnesota	23969	5 716203801	12866	2 510473314	19862	1976853437	35121	1806616287	20897	1.966391521	8736	1.340017057	1244	1 152695027	3105
5 AREA: Mississippi	1372	0.327198949	5007	0.976988954	3906	0.388761934	9489	0.488112011	12640	1.189414213	14636	2.245019419	1036	0.959961453	1546
6 AREA: Missouri	13878	3.309669838	12756	2.489009606	22026	2.192235112	51812	2.665197547	17718	1.667250082	7148	1.09643337	2031	1.881932154	4797
7 AREA: Montana	0	0	1052	0.205271096	2514	0.250216974	658	0.033847371	7611	0.716189207	1576	0.241743004	94	0.08710075	197
B AREA: Nebraska	28084	6.697562165	3291	0.642155112	9/9/	0.975089776	1/0/6	0.878385573	5673	0.627924133	1583	0.242816735	383	0.354889225	813
APEA: Nevada	6	0.036157312	2026	0.432004701	279	0.027721652	2001	0.011059551	1000	0.232742631	000	0.104741106	263	0.243636776	475
1 ABEA: New Jerseu	527	0.001430033	16376	3 195360717	18359	1827260711	37516	1929814544	25600	2 408940179	10589	1.624249155	3891	3.605415072	2884
2 AREA: New Mexico	1089	0.259708204	1152	0.224783558	6152	0.612305022	2142	0.110183995	8227	0.77415433	857	0.131455428	156	0.14455018	420
3 AREA: New York	6782	1.617393057	29209	5.699394919	28757	2.862167671	94531	4.862653233	52736	4.962416769	19354	2.968714529	4906	4.545917847	5847
4 AREA: North Carolina	11335	2.703207062	16963	3.309898867	28585	2.84504861	70595	3.631390813	32297	3.039122694	44055	6.757606622	8316	7.70563653	3794
5 AREA: North Dakota	8104	1.932667846	1133	0.22107619	2987	0.297294392	157	0.008076044	4385	0.412625105	264	0.040495021	118	0.109339239	398
AREA: Uhio	16103	3.840294956	244 14	4.763772383	54400	5.414400713	115157	5.923650002	50912	4.790779781	19704	3.022401109	6138	5.68/49363	14842
AREA: Uklanoma	4995	0.399505426	4173	1 130356902	14013	1.373600093	25303	1.204770936	9713	0.919996554	2019	6 10/317629	912	0.611008400	1/12
9 ABEA: Bennsulvania	9311	2 220517067	26774	5 224266478	68084	6 776361363	154371	7 940809281	54850	5 161342532	19030	2 919016094	4421	4 096515043	5148
0 AREA: Rhode Island	9	0.002146349	81	0.015805094	734	0.073054598	0	0	1652	0.155451921	227	0.034819582	229	0.212192252	35
1 AREA: South Carolina	2607	0.6217257	6447	1.257968402	16425	1.634770804	23333	1.200244236	17515	1.648147939	14551	2.23198125	4986	4.620046145	2396
2 AREA: South Dakota	3049	0.727135274	439	0.085659707	2281	0.227026618	52	0.002674868	962	0.090523455	694	0.10645282	88	0.081541127	260
3 AREA: Tennessee	2639	0.629357163	12880	2.513205058	33275	3.311841613	65332	3.360663285	20337	1.913695954	10392	1.594031279	2910	2.696416823	5478
AHEA: Lexas	32433 EC1	7.734725598	36800	7.180585881 0.512050220	8/394	8.698274558	96385 6616	4.958022573	93391 7661	8.788020792	42685	6.547462005	9331	8.646139306	15864
6 ABEA: Vermont	945	0.100703075	2034	0.01000239	818	0.073333043	51	0.203030331	2140	0.710043234	2430	0.373000002	1232	1 14 15 75 782	743
7 AREA: Virginia	5453	1.300448885	9426	1.839244634	17561	1.74783623	66127	3.401557905	23417	2.203521569	33104	5.077830203	2532	2.346160617	3829
8 AREA: Washington	6883	1.64147986	7729	1.50811816	17359	1.727731286	28890	1.486095058	19545	1.839169367	65089	9.984016738	1112	1.030383336	2851
9 AREA: West Virginia	548	0.130688793	1189	0.232003169	6441	0.641069026	11606	0.597010012	3873	0.364446301	1526	0.234073492	530	0.491099971	430
0 AREA: Wisconsin	7971	1.90094958	16328	3.185994736	30887	3.074165346	76647	3.942704323	16477	1.550472943	15788	2.421724965	2145	1.987564978	4645
1 AHEA: Wyoming	0	0	67	0.013073349	484	0.048172242	1051	0.054063202	4619	0.434644324	230	0.035279753	18	U.016678867	92
3	419316.75	100	512493	100	1004728	100	1944021	100	1062708	100	651932	100	107921	100	18241
🔹 🕨 🕅 % State At	tractions	/ alabama	/ arizona	/ arkansas	/ califor	nia / colora	do / con	necticut 🖌	del <						>
eady														NUM	

To simplify the calibration of the production flow distribution model, it was assumed that the form of the utility function is linear. The utility functions for flows from production state *i* to the attraction states j are thus estimated by performing linear regression analysis of the dependent variable (i.e., calculated relative utilities) with the explanatory variables (i.e., distance and fractional attraction level). However, since the dependent variables in the linear regressions are the relative utilities, the independent variables have to be relative centroidal distances, and relative fractional attraction levels. The linear equation representing the relative utility as a function of the explanatory variables is thus:

$$V_{ij|s}^{k} = \alpha_0^{k} + \alpha_1^{k} d_{ij|s} + \alpha_2^{k} F A_{j|s}^{k}$$

Where,

- $V_{ij|s}^{k}$ = Utility for flows from state *i* to state *j* relative to flows from state *i* to state *s* (In this model, state *s* is Alabama)
- $d_{ij|s} = d_{ij} d_{is}$ = Relative centroidal distances, which is the distance between state *i* and state *j* relative to the distance between state *i* and state *s*

$$FA_{j|s}^{k} = FA_{j}^{k} - FA_{s}^{k} =$$
 Relative fractional attraction level, which is the fractional attraction level of state *i* relative to the fractional attraction level of state *s*

The first step is thus to develop Excel worksheets that contain the relative utilities, the relative centroidal distances, and the relative fractional attraction levels (see the Production Flow Distribution Linear Regression Inputs workbook on the CD and the screenshot on the opposite page that illustrates the required calculations).

Calcul	lated in Ste	р					The formula for calculating the
3 Prod	luction Flor	w 😽	duction Flow Distri	ibution Linear Regres	sion Inputs.xls [Read-Only]		attractions is: E2
Distril	oution –	ŗm	nat <u>T</u> ools <u>D</u> ata <u>W</u>	indow <u>H</u> elp			attractions is: E3-
Relati	ve Utility	-	- 🔐 Σ 🚽 🏭 10	0% 🔻 🕜 🎽 Arial	▼ 10 ▼ B I U	토 클 클 쿄 \$ %	, SES 2
Calcu	5	5	1 🔊 🖣 😥 🕅 Re	eply with Changes End R	teview		
C	1984	T _k	614.08		*		\sim
	A		В	С	D	E	G
1 Ori	gin State: Alaba	ama	Relative Utility (Centroidal Distances	Relative Centroidal Distances	Fractional Attractions	Relative Fractional Attractions
2 ARI	EA: Alabama		0	0.9	0.00	2.048034094	0
4 AR	A. Anzona		-11.420761	3.32	433.32	2.64	0 59412127
5 AR	EA: California		-11.420761	211.88	2211.88	Calandatad	287373
6 AR	EA: Colorado		-11.420761	1324.48	1324.48	Calculated 1	n Step 1 358089
7 ARI	EA: Connecticu <u>t</u>		-11.42076	<u> </u>	1096.23	Attraction F	low 077345
8 ARI	EA: Delaware	Calc	culated in Ste	$\frac{3.01}{7.00}$	873.01	 Distribution 	192788
9 AR	EA: District of C	State	e to State	7.92 4.05	///.92	1 8/3/13613	034094
11 AR	EA: Georgia	State		8.62	238.62	2.416073291	0.368039197
12 AR	EA: Idaho	Cen	troidal Dista	nces B2.19	2082.19	0.744544548	-1.303489546
13 ARI	EA: Illinois		-0.400242214	002.97	602.97	12.55494802	10.50691393
14 AR	EA: Indiana		11.420761	544.04	544.04	2.667434583	0.619400489
15 ARI	=A: Iowa		-11.420761	872.02	872.02	11.39186546	9.343831364
10 AR	EA: Kansas		-11.420/61	913.70	913.70	0.838083805	3.432580895
18 AR	A: Louisiana		-11 420761	410.18	410 18	0.23633685	-1.811697243
19 AR	EA: Maine		-11.420761	1444.28	1444.28	0.019078656	-2.028955438
20 AR	EA: Maryland		-11.420761	795.52	795.52	0.557096753	-1.49093734
21 AR	EA: Massachuse	tts	-11.420761	1165.75	1165.75	0.227751455	-1.820282638
22 AR	EA: Michigan		-11.420761	867.27	867.27	2.0440395	-0.003994594
23 ARI	A: Minnesota		-5.227098663	1174.33	1174.33	5.716203801	3.668169707
24 ARI	EA: Mississippi		-11.420701	209.37	615.76	3 300660838	1 261635744
26 AR	A: Montana		-11 420761	1864 46	1864 46	0	-2 048034094
27 AR	EA: Nebraska		-11.420761	1109.02	1109.02	6.697562165	4.649528072
28 AR	EA: Nevada		-11.420761	2075.19	2075.19	0.038157312	-2.009876782
29 AR	EA: New Hampsh	nire	-11.420761	1280.01	1280.01	0.001430899	-2.046603194
30 AR	EA: New Jersey		-11.420761	943.27	943.27	0.125680646	-1.922353448
31 ARI	A: New Mexico		-11.420761	1240.55	1240.55	0.259708204	-1.78832589
33 AR	EA: New Fork EA: North Carolir	na	-11.420701	537.15	537 15	2 703207062	0.655172969
34 AR	EA: North Dakota	a	-11.420761	1476.68	1476.68	1.932667846	-0.115366248
35 ARI	EA: Ohio		-11.420761	644.89	644.89	3.840294956	1.792260862
30 ARI	EA. UNIO		-11.420701	044.09	044.89	3.840294930	1.792200802
36 ARI	EA: Oklahoma		-6.325710951	750.93	750.93	1.19122358	-0.856810514
37 AR	EA: Oregon		-11.420761	2451.53	2451.53	0.398505426	-1.649528668
38 ARI	A: Pennsylvania	3	-11.420761	8/3.16	873 1194 The form	ula for calculati	0.1/24829/4 0.045997745
40 AR	EA: Rhoue Island	u na	-11.420761	400.73	400 the relati	va controidal	-1 426308393
41 AR	EA: South Dakot	a	-11.420761	1307.26	1307 the relati		-1.320898819
42 AR	EA: Tennessee		-3.225618662	235.20	235. distances	s 1s: C53-\$C\$52	-1.418676931
43 AR	EA: Texas		-4.84410641	823.39	823.00		5.686691505
44 AR	EA: Utah		-11.420761	1766.35	1766.35	0.133789075	-1.914245019
45 AR	A: Vermont		-11.420761	1246.84	1246.84	0.201518303	-1.84651579
40 AR	EA: Virginia		-11.420761	2/32 01	2432.91	1.500440005	-0.747565209
48 AR	EA: West Virgini	а	-11.420761	631.58	631.58	0.130688793	-1.9173453
49 AR	EA: Wisconsin		-11.420761	947.04	947.04	1.90094958	-0.147084513
50 ARI	EA: Wyoming		-11.420761	1570.46	1570.46	0	-2.048034094
51 Ori	gin State: Arizo	na			//		
52 AR	EA: Alabama		0	1597.43	0.00	2.048034094	0
54 AD			11.48561648 0	0.00	-1597.43	0.005105913	-1.98292818
55 AR	A: California		7 880784345	705.03	-892.40	6 842321467	4 794287373
56 AR	EA: Colorado		0	660.27	-937.16	1.771453203	-0.27658089
57 AR	EA: Connecticut		0	2402.81	805.38	0.031956749	-2.016077345
58 AR	EA: Delaware		0	2246.71	649.28	0.153106214	-1.89492788
59 ARI	EA: District of Co	olumbia	0	2162.96	565.53	0	-2.048034094
60 ARI	EA: FIORIda		0	1980.32	382.89	1.843/13613	-0.204320481
62 AD	EA: Georgia		0	1804.33	200.90	0.74/54/549	-1 303480546
63 AP	EA: Illinois		0	1469.06	-128.37	12,55494802	10.50691393
64 AR	EA: Indiana		0	1614.66	17.23	2.667434583	0.619400489
65 AR	EA: Iowa		0	1359.19	-238.24	11.39186546	9.343831364
66 AR	EA: Kansas		0	926.57	-670.86	5.500614989	3.452580895
67 AR	EA: Kentucky		0	1692.53	95.10	0.838983895	-1.209050199
60 AR	EA: LOUISIANA		0	1303.72	-293.71	0.23033685	-1.811697243
	N agriculture	/ food / I	BM / RM / Chemica	Is Petroleum / Wood /	Textiles / Machinery / Miscell <	0.013070030	-2.020303430
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Finally, 49 dummy variables were included to account for the presence of commodity flows between production state *i* and each of the attraction states *j*. A generalized form of the utility function for performing the regression analysis is thus:

$$V_{ij|s}^{k} = \alpha_{0}^{k} + \alpha_{01}^{k} X_{01} + \alpha_{02}^{k} X_{02} + \dots + \alpha_{049}^{k} X_{049} + \alpha_{1}^{k} d_{ij|s} + \alpha_{2}^{k} F A_{j|s}^{k}$$

Where,

 X_{0n} , n = 1, 2, ..., 49 = Dummy variables with values:

 $X_{0n} = 1$ if j = attraction state $X_{0n} = 0$ if $j \neq attraction state$

Using this utility function, a regression of the relative utilities on the dummy variables, relative centroidal distances, and the relative fractional attraction levels can be run in a single step. Because of the number of independent variables (more than 15), Excel cannot be used to run the linear regression. Therefore SPSS, a statistical program, is recommended. The following two screenshots illustrate how the dummy variables were inserted in the Excel spreadsheet and how the worksheet needs to be formatted for performing the linear regression in SPSS (see also Production Flow Distribution SPSS Regression Input on the CD).

× N	licros	oft Excel -	Step 5	Pro	duc	tion	Flo	w Di	stri	buti	ion	SPS	S Re	egre	ssio	n l	npu	t.xl	8									
:0)	Eile	<u>E</u> dit ⊻iew	Insert	F	ormal	: <u>I</u>	ools	Da	ta	₩in	Idow	E	įelp												_			
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	AI	A	Ţx	Re	C	D	E	F	G	H	1	J	ĸ	L	M	N	0	P	Q	R	S	T	U	V	W	X	Y	Z AA
1	F	Relative Uti	<u>lity</u>	K01	X02	X03	X04	X05X	(06X	(07X	(08)	(09)	(10)	(11)	(12)	(13)	(14)	X15X	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24X	25X26
2		-11.42	076100	0	1	0	0	0	U	U	U	0	U	U	0	U	0	0	U	0	U	0	U	U	0	U	0	0 0
4		-11.42	076100	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
5		-11.42	076100 076100	0	0	0	1	1	U	U	0	0	0	U	0	0	0	0	0	0	0	0	0	U	0	0	0	0 0
7		-11.42	076100	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
9		-11.42	076100	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
10		-3.93	694816	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
12		-4.82 -11.42	076100	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
13		-5.45	024221	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0 0
14		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0 0
16		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0 0
17		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0 0
19		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0 0
20		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0 0
22		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0 0
24		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Ö	1	0	0 0
25 26		-7.24	200168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 0
27		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Ö	0	0	0	0	0	0	0	0 1
28 29		-11.42	076100 076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
30		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
31 32		-11.42	076100 076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
33		-4.73	647575	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
34		-11.42	076100 076100	0	0	0	0	U	U	U	U	0	U	U	0	U	0	U	U	0	U	0	U	U	U	U	0	0 0
36		-6.32	571095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
37		-11.42	076100 076100	0	U	0	0	U	U	U	U	U	U	U	U	U	0	U	U	U	U	U	U	U	U	U	U	0 0
39		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
40		-11.42	076100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
42		-3.22	561866	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
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					0 0		750.93	0.955910514
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		0 0 0	0 0	0 0	0 0	0	206.90	0.368039197
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			0 0	0 0		0 0	-238.24	9.343831364
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The next step is to import the Excel spreadsheet for each of the commodity groups into SPSS and to perform the linear regression analysis for each commodity group as follows:

- Open SPSS:
 - Click File Open Data and open one of the commodity group Excel worksheets
 - Click Analyze Regression Linear
 - Select "Relative Utilities" as the dependent variable
 - Select all the remaining variables as the independent variables
 - Click OK to perform the linear regression and to estimate the coefficients of the utility functions

The outputs of the regression analysis are the Ordinary Least Square (OLS) estimates of the coefficients: $\hat{\alpha}_0^k$, $\hat{\alpha}_{0n}^k$ (whereas n = 1, 2...49), $\hat{\alpha}_1^k$ and $\hat{\alpha}_2^k$.

- Conduct significance testing of the coefficient estimates to test which of the coefficients are statistically significant.
 - The Student's t-test is used to conduct the significance testing. The regression output provides the "t" values for each explanatory variable. Specifying, a 90% confidence level, the critical t-statistic equals 1.696. All the independent variables with "t" values less than 1.696 are thus considered statistically insignificant at a 90% confidence level and are consequently rejected.
- Delete the statistically insignificant independent variables and perform linear regression analysis on the remaining variables. However, it is advised that the rejected variables are deleted one-by-one to ensure that variables that may be statistically significant are not deleted.
- Repeat these regressions until all the variables are statistically significant.

The final output of the OLS regression analysis for the utility functions of the production flow distribution model for truck flows from production state i to attraction state j by commodity is summarized on the next page.

Commodity Category	Significant Variables	OLS Coefficient Estimates	Standard Error	t-statistic
Agriculture $(k = 1)$	Constant	1.504	0.560	2.6857
($d_{_{iT}}$	-0.003	0.000105	-28.479
Food $(k=2)$	d_{iT}	-0.004	9.8643E-05	-40.550
	FA_T^2	0.605	0.030	20.098
Building	Constant	-1.597	0.510	-3.130
Materials	$d_{_{iT}}$	-0.003	7.516E-05	-39.913
(k=3)	FA_T^3	0.557	0.040	13.847
Raw Materials	Constant	1.117	0.448	2.496
(<i>k</i> = 4)	$d_{_{iT}}$	-0.002	7.8E-05	-25.626
	FA_T^4	0.175	0.030	5.796
Chemicals and Petroleum	$d_{_{iT}}$	-0.003	7.85E-05	-38.191
(<i>k</i> = 5)	FA_T^5	0.444	0.026	16.995
Wood	Constant	3.502	0.500	7.008
(<i>k</i> = 6)	$d_{_{iT}}$	-0.004	9.23E-05	-43.307
	FA_T^6	0.165	0.053	3.104
Textiles	$d_{_{iT}}$	-0.003	9.56E-05	-31.368
(k = 7)	FA_T^7	0.720	0.040	17.955
Machinery	Constant	1.062	0.462	2.299
(<i>k</i> = 8)	$\overline{d_{_{iT}}}$	-0.003	9.798E-05	-30.617
	FA_T^8	0.260	0.028	9.386
Miscellaneous	$d_{_{iT}}$	-0.003	0.0001	-29.987
(k = 9)	FA_T^9	0.128	0.025	5.113

 Table 2: Outputs of the OLS Regression Analysis for the Production Flow Distribution

 Model

Attraction Flow Distribution

For the attraction flow distribution model, utility equations need to be developed for commodity flows to attraction state j from each of the production states i as a function of a set of independent variables that impact the attraction flow distribution of commodities. The two independent variables considered in developing the utility equations are:

- a) distance, which represents an impedance measure for commodity flows between states calculated in Step 4 (see the workbook State to State Centroidal Distances on the CD), and
- b) the fractional production level of the production states calculated in the workbook Production Flow Distribution on the CD. The fractional production level of the production states is determined by calculating the flows of commodity group k originating in production state i as a percentage of the total commodity k flows originating in all production states (see screenshot on opposite page).

In other words, the distribution of commodity flows to attraction state j from the production states i can be estimated considering the inter-state centroidal distances and the percentage of the commodity flows originating from production state i as a percentage of the total commodity flows originating in all production states (i.e., fractional production level of production states).

Fractional Production Level of Origin States

Total flows originating in Alabama as a percentage of the total agricultural flows originating in all production states (i.e., C3/C\$53*100).

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Microsoft Excel - Step 1 Production Flow D

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		I otal	1 100077004	Total	%	Iotal	2 110110710	Iotal	%	l otal	%	I otal	7.045300000	I otal	%	
ł	AHEA: Alabama	6127	1.468677635	5770	1.125869036	24309	2.4 19448/49	4 18 10	2.150696932	20600	1.938431282	47786	7.315766268	2886	2.6/4128///	- 3
ł	AHEA: Arizona	189	0.045304402	7884	1.538362475	21292	2.119169969	9251	0.475869345	13051	1.228080906	2191	0.335429705	546	0.000916200	
ł	AREA: Arkansas	10304	2.469928903	5/38	1.131332526	9306	0.926216219	14053	0.723397535	10496	1002200603	21060	3.300714032	927	0.85894573	
ł	AREA: California	29706	7.120701475	64039	12.49558531	96079	9.562640025	191617	9.856735087	130909	12.3183544	51998	7.96059964	7656	7.09394661	- 14
ł	AHEA: Lolorado	7718	1.850049619	8046	1.563372663	16/00	1.662133124	18204	0.936409638	5011	0.471528114	3703	0.566908352	343	0.317819186	
+	AREA: Connecticut	1	0.000239706	2674	0.521/63224	4495	0.447382538	10506	0.540426261	9/2/	0.91529714	1998	0.305882497	427	0.395652456	
ł	AHE A: Delaware	658	0.15/726438	997	0.194539242	294	0.029261505	0	0	190	0.01/8/8/35	257	0.039345246	256	0.237206156	
ł	AHEA: District or Columbia	0	1.000400104	4	0.000780498	11/0	0.116448848	70070	1.0.40700005	0	0.000770054	1409	0.215709929	0000	0 001054540	
	AREA: Florida	8216	1.969423124	22121	4.434597155	55780	5.551/23692	78670	4.046766985	64090	6.030779654	30936	4.736126591	2398	2.221954542	
4	AHEA: Georgia	11371	2.725695027	16055	3.132725715	30876	3.07305523	111922	5.757242334	291/5	2.745326828	14365	2.199200235	9873	9.148188987	5
+	AHE A: Idaho	4068	0.975123329	2332	0.455030605	4381	0.43603624	9253	0.475972225	1840	0.1/3141435	2192	0.3355828	100	0.092658655	
ļ	AREA: Illinois	51703	12.39351068	28803	5.620174324	29676	2.953620514	67195	3.456495583	50466	4.748780247	8535	1.306660216	6172	5.718892173	1
Ļ	AHEA: Indiana	10671	2.55/900944	13887	2.709695547	45183	4.49/015625	85897	4.418522228	48632	4.5/6203404	/4/9	1.14499259	2137	1.980115453	1
ļ	AREA: Iowa	51229	12.27989012	16041	3.129993971	18804	1.871541992	52249	2.687676728	15796	1.486381579	2630	0.402638122	1017	0.942338519	- 3
l	AREA: Kansas	26072	6.249610478	6709	1.309091051	7980	0.794240858	18122	0.932191576	6773	0.637329858	3308	0.506436086	960	0.889523086	
	AHEA: Kentucky	3348	0.802535129	6206	1.210943369	18219	1.813317568	92034	4.734208118	16713	1.572670001	6850	1.048696249	1803	1.670635546	5
ļ	AREA: Louisiana	949	0.227480836	4987	0.973086462	2420	0.24086001	17904	0.920977705	20683	1.946241466	32230	4.93423067	854	0.791304912	
1	AREA: Maine	0	0	710	0.138538478	960	0.095547772	918	0.047221712	6140	0.57776544	8177	1.251852442	172	0.159372886	
	AREA: Maryland	2623	0.6287484	8896	1.735828587	20268	2.017252345	29302	1.507288244	9950	0.936281129	4409	0.674992958	634	0.587455871	
I.	AREA: Massachusetts	0	0	7463	1.456215012	12852	1.279145803	24015	1.235326162	12245	1.15223743	5513	0.844009112	1938	1.79572473	
	AREA: Michigan	7995	1.916448135	16933	3.304045128	59190	5.891117342	61807	3.179338083	50390	4.741628753	12619	1.931897513	2851	2.641698248	2
	AREA: Minnesota	21098	5 057313665	15730	3 069310215	19649	1955643937	34997	1800237755	20487	1.92779814	8391	1.284614631	10.91	1 010905924	
L	AREA: Mississippi	1406	0.337026401	3992	0.778937468	2368	0.235684505	7698	0.395983377	12252	1.15289612	16002	2.449815674	1258	1.165645877	
Į.	AREA: Missouri	14559	3.489877223	13062	2.548717739	20752	2.065424347	47181	2.426979955	18799	1.768959693	5577	0.85380715	1173	1.086886021	
	AREA: Montana	0	0	1050	0.204880847	2265	0.225433025	910	0.046810194	8360	0.786664346	1823	0.279090987	24	0.022238077	
L	AREA: Nebraska	28067	6.727823615	7514	1.466166367	9183	0.91397416	16911	0.86989801	6419	0.604018951	1085	0.166107362	255	0.23627957	
	AREA: Nevada	69	0.016539702	2151	0.41971305	9382	0.933780417	2839	0.146037517	2569	0.241739319	522	0.079915247	200	0.18531731	
	AREA: New Hampshire	0	0	892	0.174051158	158	0.015725571	709	0.036470799	1475	0.138795444	765	0.117117172	1208	1.11931655	
	AREA: New Jersey	335	0.080301454	16076	3.136823332	15888	1.581315633	34801	1.790155559	28178	2.651510518	7554	1.156474666	5327	4.93592654	2
T	AREA: New Mexico	100	0.023970583	767	0.149660581	5437	0.54113879	2055	0.105708735	9248	0.870223908	776	0.11880121	82	0.075980097	
Ι	AREA: New York	6272	1.503434985	31318	6.110912734	24386	2.427112477	93075	4.787756922	50080	4.712458185	16360	2.504623449	2783	2.578690363	4
1	AREA: North Carolina	10933	2.620703872	16505	3.220531793	25094	2.497578959	73353	3.773261709	31612	2.974645131	46763	7.159150755	11367	10.53250929	
T	AREA: North Dakota	11232	2.692375916	925	0.18049027	2514	0.250215729	157	0.008076044	4378	0.411963697	234	0.035824076	35	0.032430529	
T	AREA: Ohio	16891	4.048871225	26111	5.094898857	64125	6.382292609	116468	5.991087545	54779	5.154627534	17952	2,748349643	6564	6.0821141	1
t	AREA: Oklahoma	2242	0.537420478	2545	0.496592149	15064	1.499303795	23559	1.211869625	12211	1.149038077	3169	0.485155973	758	0.702352603	
T	AREA: Oregon	1932	0.463111669	5420	1.057575421	13542	1.347820764	18376	0.945257279	8726	0.821104435	43782	6.702776519	695	0.643977651	
t	AREA: Pennsulvania	8384	2.009693704	25021	4.882213025	79464	7.90896686	161271	8.295743719	53526	5.036721981	20094	3.076277725	4773	4.422597593	
t	AREA: Rhode Island	0	0	0	0	135	0.013436405	0	0	2665	0.250772785	202	0.030925057	78	0.072273751	
t	AREA: South Carolina	1637	0.392398449	5623	1.097185718	16796	1.671687901	22259	1.144997919	14620	1.375721619	19204	2.94002376	6942	6.432363815	
t	AREA: South Dakota	2704	0.648164572	630	0.122928508	1990	0.19806257	297	0.015277613	354	0.033310906	854	0.130742569	36	0.033357116	
t	ABEA: Tennessee	2529	0.606216052	14584	2.845697405	31659	3.150986381	65644	3.376712494	22680	2.134156382	10464	1.601979204	3505	3.24768585	6
t	AREA: Texas	32325	7.748491052	36916	7.203220337	89473	8.905151916	93778	4.823919083	90029	8.471603393	37337	5,716083479	9215	8.538495038	1
1	ABEA: Litah	0	0	1928	0.37620026	9062	0.90193116	5402	0.277877657	7835	0.737262577	1893	0.289807591	395	0.366001686	
t	BEA: Vermont	1377	0.330074932	182	0.03551268	704	0.070068366	81	0.004166622	1771	0 166648631	1018	0 155850041	29	0.02687101	
t	ABEA: Virginia	4675	1120624769	10249	1 999832193	14825	1 475516381	68259	3 511227502	24660	2 320471622	33179	5.079517202	2809	2 602781613	
t	ABEA: Washington	7111	1704548179	8100	1580509392	16561	1648298603	35777	1840360778	19471	1.832193956	65346	10 00410293	949	0.879330634	- `
t	ABEA: West Virginia	438	0.104991155	564	0.110050284	8531	0.849081298	6003	0.309101599	4149	0.390415116	2862	0.438156009	632	0.585602698	
t	ABEA: Wisconsin	7914	1.897031962	17670	3 447851971	25195	2 507631381	76635	3 942087045	15814	1488075354	19685	3.013662139	1789	1657663334	
ł	VBFA: Wuoming	0	037331362	7	0.001365872	297	0.029560092	781	0.040174492	6691	0.629613772	154	0.023576529	1	0.000926597	
ł	STES. WYUTING	U	U	(0.001000072	2.31	0.020000000	701	0.0401/4400	0031	0.023013772	1.04	0.020070020		0.000020007	
ł		417170	100	E12402	100	1004700	100	1944001	100	1002715	100	652102	100	107000	100	
ł		41/1/8	100	512493	100	1004733	IUU	1344021	100	1062715	UU	655192	100	iur 323	100	

Similar to the calibration of the production flow distribution model, it was assumed that the form of the utility function is linear. The utility functions for flows to attraction state j from the production states i are thus estimated by performing linear regression analysis of the dependent variable (i.e., the calculated relative utilities) with the explanatory variables (i.e., distance and fractional production level). However, since the dependent variables in the linear regressions are the relative utilities, the independent variables have to be relative centroidal distances and relative fractional attraction levels. The linear equation representing the relative utility as a function of the explanatory variables is thus:

$$V_{ji|s}^{k} = \beta_{0}^{k} + \beta_{1}^{k} d_{ji|s} + \beta_{2}^{k} F P_{i|s}^{k}$$

Where,

- $V_{ji|s}^{k}$ = Utility for flows of commodity group k to attraction state j from production state i relative to flows from production state s to attraction state j (In this model, state s is Alabama)
- $d_{ji|s} = d_{ji} d_{js}$ = Relative centroidal distances, which is the distance between state *j* and state *i* relative to the distance between state *j* and state *s*

$$FP_{i|s}^{k} = FP_{i}^{k}$$
 - FP_{s}^{k} = Relative fractional production level, which is the fractional production level of state *i* relative to the fractional production level of state *s*

The first step is thus to develop Excel worksheets for each commodity group that contain the relative utilities, the relative centroidal distances, and the relative fractional production levels (see the Attraction Flow Distribution Linear Regression Inputs workbook on the CD and the screenshot on the opposite page that illustrates the required calculations).

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1 Destina	ation: Alabama	Relative Utility Cer	troidal Distance:	Relative Centroidal Distances	sFractional ProductionsR	elative Fractional Productior	is 🔒
2 AREA:	Alabama	0	0.00	0.00	1.46 77639	0	
3 AREA:	Arizona	-11.40/08/06	1597.43	1597.43		-1.423373236	
5 AREA	California	-5.191053525	2211.88	433.32	Calculated in	Step 1 23836	
6 AREA:	Colorado	-11.40708	1324.48	1324.48	Droduction E	10m 17198	
7 AREA:	Connecticut	-11.407	1096.23	1096.23	FIOUUCUOILE	10W 37933	
8 AREA:	Delaware	-11/	873.01	873.01	Distribution	51201	
10 AREA:	Calculate	ed in Step 4	434.05	434.05	1 969723124	77639	
11 AREA:	State to S	State	238.62	238.62	2.725695027	1.257017388	
12 AREA:			2082.19	2082.19	0.975123329	-0.49355431	
13 AREA:	Centroid	al Distances	602.97	602.97	12.39351068	10.92483304	
14 AREA:	0000	11 /0709700	544.04	544.04	2.557900944	1.089223305	
16 AREA:	iuwa Kansas	-11.40708706	913.70	913.70	6 249610478	4 780932839	
17 AREA	Kentuckv	-5.368734702	395.94	395.94	0.802535129	-0.66614251	
18 AREA:	Louisiana	-11.40708706	410.18	410.18	0.227480836	-1.241196803	
19 AREA:	Maine	-11.40708706	1444.28	1444.28	0	-1.468677639	
20 AREA:	Maryland	-11.40708706	795.52	795.52	0.6287484	-0.839929239	
21 AREA:	Massachusetts	-11.40/08/06	1165.75	1165.75	1.01040105	-1.468677639	
22 AREA.	Minnesota	-11.40708706	117/133	1174 33	5.057313665	3 588636026	
24 AREA:	Mississippi	-6.244203439	209.37	209.37	0.337026401	-1.131651238	
25 AREA:	Missouri	-11.40708706	615.76	615.76	3.489877223	2.021199584	
26 AREA:	Montana	-11.40708706	1864.46	1864.46	0	-1.468677639	
27 AREA:	Nebraska	-11.40708706	1109.02	1109.02	6.727823615	5.259145976	
28 AREA:	Nevada Nevu Hananahira	-11.40/08/06	2075.19	2075.19	0.016539702	-1.452137936	
29 AREA.	New Jarsey	-11.40708706	9/3 27	9/3 27	0.080301454	-1.400077039	
31 AREA:	New Mexico	-11.40708706	1240.55	1240.55	0.023970583	-1.444707056	
32 AREA:	New York	-11.40708706	1092.50	1092.50	1.503434985	0.034757346	
33 AREA:	North Carolina	-11.40708706	537.15	537.15	2.620703872	1.152026233	
34 AREA:	North Dakota	-11.40708706	1476.68	1476.68	2.692375916	1.223698277	
	Ohio	11 40709700	C44 00	C44.90	4 040071005	1 50010350C	
36 AREA	Oklahoma	-11.40708706	750.93	750.92	0.637/20/78	2.000190000 0.031257161	
37 AREA:	Oregon	-11.40708706	2451.53	2451.5 701	1. 6 1 1	565969	
38 AREA:	Pennsylvania	-11.40708706	873.16	873.10 I ne IC	ormula for calcul	ating ₁₁₆₀₆₅	
39 AREA:	Rhode Island	-11.40708706	1164.45	^{1164.4} the rel	lative centroidal	677639	
40 AREA:	South Carolina	-11.40708706	400.73	400.71 400.71 distant	ces is C53-SCS	52 527919	
41 AREA:	South Dakota	-11.40/08/06	1307.26	1307.2 CIStan	$\cos 13.$ $\cos 15-\phi c\phi$	JZ 513066 461597	
42 AREA	Texas	-5.907731203	823.39	823.39	48491052	6 279813413	
44 AREA:	Utah	-11.40708706	1766.35	1766.35	0	-1.468677639	
45 AREA:	Vermont	-11.40708706	1246.84	1246.84	0.330074932	-1.138602707	
46 AREA:	Virginia	-11.40708706	643.93	643.93	1.120624769	-0.34805287	
47 AREA:	Washington	-11.40708706	2432.91	2432.91	1.704548178	0.23587054	
48 AREA:	vvest Virginia	-11.40/08706	631.58	631.58	0.104991155	-1.363686484	
50 AREA:	Wyoming	-11.40708706	1570.46	1570.46	n.097031962	-1 468677639	
51 Destina	ation State: Arizo	n relative utility	1010.40	1010.40		1.400011000	
52 AREA:	Alabama	0	1597.43	0.00 //	1.468677639	0	
53 AREA:	Arizona	0	0.00	-1597.43	0.045304402	-1.423373236	
54 AREA:	Arkansas	0	1214.48	-382.95	2.469928903	1.001251264	
55 AREA:	Colorada	11.020/1158	705.03	-892.40	7.120/014/5	5.652023636	
57 AREA:	Connecticut	0.007043304	2402.81	-537.16	0.000239706	-1.468437933	
58 AREA:	Delaware	Ō	2246.71	649.28	0.157726438	-1.310951201	
59 AREA:	District of Columb	ia O	2162.96	565.53	0	-1.468677639	
60 AREA:	Florida	0	1980.32	382.89	1.969423124	0.500745485	
61 AREA:	Georgia	0	1804.33	206.90	2.725695027	1.257017388	
62 AREA:	Idaho	8.899185943	957.99	-639.44	0.975123329	-0.49355431	
64 ADEA	Indiana	0	1409.00	-128.3/	2,59351068	10.92483304	
65 AREA	lowa	0	1359,19	-238.24	12.27989012	10.81121248	
66 AREA:	Kansas	0	926.57	-670.86	6.249610478	4.780932839	
67 AREA:	Kentucky	0	1692.53	95.10	0.802535129	-0.66614251	
68 AREA	Louisiana agriculture / foor	1 / BM / RM / Chemic	1303.72 als & Petroleum /	⊥293,71 Wood / Textiles / Machinery / M	0.227480836	-1 241196803	

Finally, 49 dummy variables were included to account for the presence of commodity flows between attraction state *j* and each of the production states *i*. A generalized form of the utility function for performing the regression analysis is thus:

$$V_{ji|s}^{k} = \beta_{0}^{k} + \beta_{01}^{k} X_{01} + \beta_{02}^{k} X_{02} + \dots + \beta_{049}^{k} X_{049} + \beta_{1}^{k} d_{ji|s} + \beta_{2}^{k} F P_{i|s}^{k}$$

Where

 X_{0n} , n = 1, 2..., 49 = Dummy variables with values:

 $X_{0n} = 1$ if i = production state $X_{0n} = 0$ if $i \neq production state$

Using this utility function, a regression of the relative utilities on the dummy variables, relative centroidal distances, and the relative fractional production levels can be run in a single step. Because of the number of independent variables (more than 15), Excel cannot be used to run the linear regression. Therefore SPSS, a statistical program, is recommended. The following two screenshots illustrate how the dummy variables were inserted in the Excel spreadsheet and how the worksheet needs to be formatted for performing the linear regression in SPSS (see also Attraction Flow Distribution SPSS Regression Input on the CD).

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33 -10947498 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	37	-10.9474	698	0	0	0	0	0	0	0	0	0	0	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
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43 -2.87965387 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <t< td=""><th>42</th><td>-1.544441</td><td>1831</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0 0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></t<>	42	-1.544441	1831	0	0	0	0	0	0	0	0	0	0	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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44 -5.44742285 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <t< th=""><th>45 40</th><th>-10.9474</th><th>698</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0 0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th><th>0</th></t<>	45 40	-10.9474	698	0	0	0	0	0	0	0	0	0	0	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 -10.9474898 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <	40	-5.24379	2505 698	0	0	0	0	0	0	0	0	0	0	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Solution Solution <th< td=""><th>58</th><td>0</td><td></td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0 0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></th<>	58	0		0	0	0	0	0	0	1	0	0	0	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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689 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	68	4.03669U 0	211	0	0	0	0	0	0	0	0	0	0	0	0 0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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The same procedure and steps for performing the linear regression analysis for the production flow distribution of commodities is required for the attraction flow distribution of commodities (see page 35 of the manual). The final output of the OLS regression analysis for the utility functions of the attraction flow distribution model for truck flows to attraction state j from production state i by commodity is summarized on the next page.

Commodity Group	Significant Variables	OLS Coefficient Estimates	Standard Error	t-statistic
Agriculture	Constant	1.185	0.547	2.168
(k=1)	$d_{_{iT}}$	-0.002	8.9E-05	-22.467
	FP_T^1	0.126	0.028	4.414
Food $(k=2)$	$d_{_{iT}}$	-0.003	8.218E-05	-36.502
(n-2)	FP_T^2	0.504	0.031	16.520
Building Materials	$d_{_{iT}}$	-0.004	8.986E-05	-44.510
(k = 3)	FP_T^3	0.409	0.031	13.319
Raw Materials	$d_{_{iT}}$	-0.002	8.857E-05	-22.580
(k = 4)	FP_T^4	0.104	0.028	3.649
Chemicals and	$d_{_{iT}}$	-0.003	8.603E-05	-34.871
Petroleum $(k = 5)$	FP_T^5	0.371	0.028	13.205
Wood	Constant	1.060	0.457	2.319
(k = 6)	$d_{_{iT}}$	-0.004	9.249E-05	-43.244
	FP_T^6	0.493	0.035	14.050
Textiles	$d_{_{iT}}$	-0.003	9.203E-05	-32.598
(<i>k</i> = 7)	FP_T^7	0.431	0.033	13.167
Machinery	Constant	1.525	0.503	3.034
(<i>k</i> = 8)	$d_{_{iT}}$	-0.003	8.185E-05	-36.650
	FP_T^8	0.096	0.041	2.360
Miscellaneous	$d_{_{iT}}$	-0.003	0.000106	-28.300
(k=9)	FP_T^9	0.168	0.025	6.685

 Table 3: Outputs of the OLS Regression Analysis for the Attraction Flow Distribution

 Model

Step 6: Compute Disaggregate Texas County Truck Flows

Step 6 requires the application of the calibrated MNL models to the state-level truck flows reported in the CFS to generate:

- Texas county-to-state truck flows (Internal-External),
- State-to-Texas county truck flows (External-Internal), and
- Texas county-to-county truck flows (Internal-Internal)

Step 6(a): Develop State-to-County and County-to-County Centroidal Distance Matrices

The first step in the computation of Texas county truck flows is the development of the state-tocounty and county-to-county centroidal distance matrices. The procedure for calculating the state-to-county and county-to-county centroidal distances is the same as for the state-to-state centroidal distances (see page 27 of this manual). However, developing the state-to-county and county-to-county centroidal distance matrices requires a Texas county layer to be added to the U.S. State and highway layers on the map and the state and county centroids to be connected to the highway layer using the *centroid connectors* feature in TransCAD. A new highway network is then created to include the state and county centroids. The state-to-county and county-tocounty centroidal distances are subsequently computed as the shortest path distance along the highway network (see County to State Centroidal Distances on the CD).

Step 6(b): Compute Texas County-to-State Truck Flows

Texas county-to-state truck flows for the nine commodity groups are estimated from the Texasto-state truck flows reported in the CFS and the utility equations for the attraction flow distribution model developed in Step 5. In addition, disaggregating the Texas-to-state truck flows to generate Texas county-to-state truck flows using the calibrated attraction flow distribution model requires the fractional production level by each of the Texas counties of each commodity group.

Fractional Production Level of Texas Counties

The fractional production level of each commodity group originating in each of the Texas counties was calculated from the data captured in the IMPLAN database developed by the Minnesota IMPLAN Group (MIG) Inc. The IMPLAN database provides the industry output (millions of dollars) for a total of 528 industries for each county in Texas (for example, see opposite page for a screenshot of the industry output for Angelina County captured by IMPLAN). These 528 industries were grouped into the commodity groups listed in Table 1 on page 8 of the manual to compute the total commodity group output in millions of dollars for each of the Texas counties. The industry output for each Texas county for each commodity group was saved in an Excel file (see County Productions for each commodity group on the CD).
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	A1 The factor	Angelina County							
	Δ	в	С						
1	Angelina County	Industry	Industry Output (Millions of Dollars)						
2	1	Dairy Farm Products	0.000						
3	2	Poultry and Eggs	8.469						
4	3	Ranch Fed Cattle	3.317						
5	4	Range Fed Cattle	0.685						
6	5	Cattle Feedlots	0.236						
7	6	Sheep, Lambs and Goats	0.008						
8	7	Hogs, Pigs and Swine	0.028						
9	8	Other Meat Animal Products	0.000						
10	9	Miscellaneous Livestock	0.433						
11	10	Cotton	0.000						
12	11	Food Grains	0.009						
13	12	Feed Grains	0.000						
14	13	Hay and Pasture	1.892						
15	14	Grass Seeds	0.000						
16	15	Tobacco	0.000						
17	16	Fruits	0.028						
18	17	Tree Nuts	0.000						
19	18	Vegetables	0.217						
20	19	Sugar Crops	0.000						
21	20	Miscellaneous Crops	0.000						
22	21	Oil Bearing Crops	0.000						
23	22	Forest Products	1.391						
24	23	Greenhouse and Nursery Products	2.975						
25	24	Forestry Products	39.814						
26	25	Commercial Fishing	0.064						
27	26	Agricultural, Forestry, Fishery Services	0.493						
28	27	Landscape and Horticultural Services	3.403						
29	28	Iron Ores	0.000						
30	29	Copper Ores	0.000						

However, the county productions for each commodity group obtained from IMPLAN are in millions of dollars. Since the commodity tonnage produced are required, the value data were converted to tonnage by applying a value to weight factor for each commodity group that was calculated from the CFS data. The value to weight factors that were used are summarized in Table 4.

Commodity Group	Value:Weight (\$ Million/1000 tons)
Agriculture	0.553
Food	5.4136
Building Materials	0.9453
Raw Materials	0.1369
Chemicals/Petroleum	5.62
Wood	1.9228
Textiles	6.48
Machinery	20.977
Miscellaneous	1.1731

 Table 4: Value to Weight Conversion Factors

Once the total commodity tonnage produced in each county are calculated, the fractional productions in each county for each commodity group can be determined. The Excel screenshot on the opposite page illustrates the required calculations for agricultural commodities.

The formula for calculating agricultural tonnage is: B3/0.553. The formula for calculating the fraction: productions for each commodil yzero data agricultural tonnage is: B3/0.553. The formula for calculating the fraction: productions for each commodil yzero data agricultural tonnage is: B3/0.553. The formula for calculating the fraction: tonnage productions for each commodil yzero data agricultural tonnage produced in a former data agricultural composition of the formula for the calculating the fraction: toras counties: a former data agricultural composition of the formula for the calculating the fraction: toras counties: a former data agricultural composition of the formula former data agricultural composition of the former data agricultural compositis composition of the former data agricultural composition						Г		
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16 BELL TX 73 96451624 133 7513856 0.413281192 40 16612328 293 5436324 0.06057446 17 BEXAR TX 229.2611765 414.5771727 1.261010639 1614.586867 11793.91444 2.433743615 18 BLANCO TX 15.66685723 28.3308491 0.067540068 2.496831805 18.2338524 0.007635364 19 BORDEN TX 14.40656532 26.05165519 0.080497552 0 0 0 0 20 DOSQUE TX 44.62315013 80.89285738 0.24933454 21.39513946 156.2829763 0.032249914 21 BOVNE TX 61.01734753 110.338744 0.349938106 48.92745292 257.395767 0.073750728 22 BRAZOS TX 69.33893301 125.9293545 0.38911735 263.5009668 1924.769662 0.397187574 23 BRAZOS TX 9.547312217 17.2647905 0.053346162 5.311076149 38.75599830 0.000005638 25 BRISCOE TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004247876 27 BROWN	15	BEE TX	32.63920854	59.02207693	0.182373545	62.79593852	458.6993318	0.094655313
17 BEXAR TX 229 2611765 414 5771727 1.281010639 1614 566687 11793.91444 2.433743815 18 BLANCO TX 15.66695723 28.33084491 0.087540068 2.49631805 18.23836234 0.00373594 19 BORDEN TX 14.40656532 28.03084491 0.080497552 0 0 0 20 BOSQUE TX 44.62315013 80.89285738 0.24933454 21.39513946 156.2829763 0.032249914 21 BOXME TX 61.01734753 110.338784 0.340938106 48.82748292 357.3957847 0.073750728 22 BRAZORIA TX 89.34471827 161.568658 0.499218997 108.0338439 769.144211 0.162844565 23 BRAZOR TX 9.54731217 17.26457905 0.033346182 5.311076149 38.79529693 0.008005638 25 BRISOE TX 25.84609162 46.73759595 0.144416594 14.6536864 106.9091201 0.020201328 26 BROWN TX 13.51406567 24.437178 0.075510565 2.9507965612 2.56439274 0.006447876 27 BROWN TX <t< td=""><td>16</td><td>BELL TX</td><td>73.96451624</td><td>133.7513856</td><td>0.413281192</td><td>40.18612328</td><td>293.5436324</td><td>0.06057446</td></t<>	16	BELL TX	73.96451624	133.7513856	0.413281192	40.18612328	293.5436324	0.06057446
18 BLANCO TX 15.66695723 28.33084491 0.087540068 2.496831605 18.23836234 0.003763594 19 BORDEN TX 14.40656532 26.05165519 0.080497552 0 0 0 0 20 BOSQUE TX 44.62315013 80.69285738 0.24933454 21.39513946 155.2829763 0.03224914 21 BOWE TX 61.01734753 110.338784 0.340938106 48.92748292 357.3957847 0.073750728 22 BRAZORIA TX 89.34471627 161.5636858 0.499218997 108.0338439 789.1442211 0.162844565 23 BRAZOS TX 69.5389301 125.923545 0.389111735 263.5009668 1924.789662 0.397187574 24 BREWSTER TX 9.547312217 17.26457905 0.053346182 5.311076149 38.79529633 0.008006588 25 BROKS TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004747876 26 BROWN TX 40.54259543 73.31391578 0.226534195 44.6524872 326.1712836 0.067307368 29	17	BEXAR TX	229.2611765	414.5771727	1.281010639	1614.586887	11793.91444	2.433743815
19 BORDEN TX 14.40656522 26.05165519 0.080497552 0 0 0 20 BOSQUE TX 44.62315013 80.69265738 0.24933454 21.39513946 156.2829763 0.032249914 21 BOWE TX 61.01734753 110.338784 0.349938106 48.92748292 357.3957847 0.03750728 22 BRAZORIA TX 89.34471827 161.5636858 0.499218997 108.0338439 789.1442211 0.162844565 23 BRAZOS TX 69.6393301 125.9239545 0.389111735 253.5009668 1924.769662 0.397187574 24 BREVNSTER TX 9.547312217 17.26457905 0.053346182 5.311076149 38.9529693 0.008005638 25 BRISCOE TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004447876 26 BOONN TX 40.54259543 73.3131578 0.226534195 44.65284872 326.1712836 0.067307368 28 BURLESON TX 36.67901571 66.32733402 0.2049446211 61.53119889 448.4509123 0.092748911 30 CALDWEL TX<	18	BLANCO TX	15.66695723	28.33084491	0.087540068	2.496831805	18.23836234	0.003763594
20 BOSQUE TX 44.62315013 80.68285738 0.24933454 21.39513946 156.2829763 0.032249914 21 BOWIE TX 61.01734753 110.338784 0.340938106 48.92746292 357.3957847 0.073750728 22 BRAZORIA TX 89.34471827 161.5636858 0.499218997 108.038439 789.1442211 0.162844565 23 BRAZORIA TX 9.547312217 17.26457905 0.053346162 5.311076149 38.79529693 0.008005638 24 BREVXSTER TX 9.547312217 17.26457905 0.053346162 5.311076149 38.79529693 0.008005638 25 BRISCOE TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004447876 26 BROOKN TX 13.51406567 24.43773178 0.0256510556 2.950796366 562.0782823 0.115988169 27 BRCWN TX 40.54259543 73.31391578 0.226534195 44.65284872 36.112836 0.0067307368 28 BURNET TX 36.67901571 66.32733402	19	BORDEN TX	14.40656532	26.05165519	0.080497552	0	0	0
21 BOWLE TX 61.01734753 110.338784 0.340938106 48.92748292 357.3957847 0.073750728 22 BRAZORIA TX 89.34471827 161.656888 0.499218997 108.0338439 789.1442211 0.162844565 23 BRAZOR TX 69.63893301 125.9293545 0.389111735 263.5009668 1924.769662 0.397187574 24 BREVNSTER TX 9.547312217 17.26457905 0.053346182 5.311076149 38.75239833 0.008005638 25 BRISCOE TX 25.84609162 46.73795953 0.144416594 14.63585654 106.9091201 0.022061328 26 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 326.1712836 0.067307368 27 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 30.1712836 0.067307368 28 BULESON TX 35.38172094 63.38141219 0.197697498 76.94851665 562.0782823 0.115988169 30 CALDWELL TX 38.51121892 68.64054055 0.215183756 23.1553715 168.1419806 0.039403445 31 <t< td=""><td>20</td><td>BOSQUE TX</td><td>44.62315013</td><td>80.69285738</td><td>0.24933454</td><td>21.39513946</td><td>156.2829763</td><td>0.032249914</td></t<>	20	BOSQUE TX	44.62315013	80.69285738	0.24933454	21.39513946	156.2829763	0.032249914
22 BRAZORIA TX 89.34471827 161.5638658 0.499218997 108.0338439 799.1442211 0.162844565 23 BRAZOS TX 69.63893301 125.9293545 0.389111735 263.5009668 1924.769662 0.397187574 24 BREWSTER TX 9.547312217 17.26457905 0.053346182 5.311076149 38.79529693 0.008005638 25 BRSCOE TX 25.84609162 46.73795953 0.144416594 14.6526854 106.0991201 0.022051328 26 BROWN TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004447876 27 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 326.1712836 0.067307368 28 BURLESON TX 35.38172094 63.3873402 0.204946211 61.33119889 449.4609123 0.092748911 29 BURNET TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 23.15553715 <td>21</td> <td>BOWIE TX</td> <td>61.01734753</td> <td>110.338784</td> <td>0.340938106</td> <td>48.92748292</td> <td>357.3957847</td> <td>0.073750728</td>	21	BOWIE TX	61.01734753	110.338784	0.340938106	48.92748292	357.3957847	0.073750728
23 BRAZOS TX 69.63893301 125.9293545 0.389111735 263.5009668 1924.769662 0.397187574 24 BREVNSTER TX 9.547312217 17.26457005 0.053346182 5.311076149 38.79529693 0.008005638 25 BRISCOE TX 25.84609162 46.73795953 0.144416594 14.6358584 106.9091201 0.022061328 26 BROOKS TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004447876 27 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 326.1712836 0.067307368 29 BURLESON TX 35.38172094 63.98141219 0.197697498 76.94851685 562.078223 0.115988169 29 BURNET TX 36.67901571 66.3273402 0.204946211 61.53119889 449.4609123 0.092748911 20 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.1555715 169.1419806 0.034903445 31 CALLOUN TX 84.14424891 152.1595821	22	BRAZORIA TX	89.34471827	161.5636858	0.499218997	108.0338439	789.1442211	0.162844565
24 BREWSTER TX 9.547312217 17.26457905 0.053346182 5.311076149 38.79529693 0.008005638 25 BRISCOE TX 25.84609162 46.73739553 0.144416594 14.63585854 106.9091201 0.022061328 26 BROOKS TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004447876 27 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 326.1712836 0.067307368 28 BURLESON TX 35.38172094 63.98141219 0.197897498 76.94851685 562.0782823 0.115988169 29 BURNET TX 36.67901571 66.32733402 0.204946211 61.53119889 449.4609123 0.092748911 30 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.64376847 337.1386704	23	BRAZOS TX	69.63893301	125.9293545	0.389111735	263.5009668	1924.769662	0.397187574
25 BISCOE TX 25.84609162 46.73795953 0.144416594 14.6356854 106.9091201 0.022061328 26 BROOKS TX 13.51406567 24.43773178 0.075510656 2.950796366 21.55439274 0.004447876 27 BROWN TX 40.54259543 73.31391578 0.226534195 44.6528472 326.1712836 0.067307368 28 BURLESON TX 35.38172094 63.98141219 0.197697498 76.94851685 562.0782823 0.11988169 29 BURNET TX 36.67901571 66.32733402 0.204946211 61.53119889 449.4609123 0.092748911 30 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 33 CAMERON TX 186.4376847 337.1386704	24	BREWSTER TX	9.547312217	17.26457905	0.053346182	5.311076149	38.79529693	0.008005638
2b BROCKS TX 13.51406567 24.33773178 0.075510656 2.950796366 21.55439274 0.004447876 27 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 326.1712836 0.067307368 28 BURLES ON TX 35.38172094 63.98141219 0.197697498 76.94851685 562.0782823 0.115988169 29 BURNET TX 36.67901571 66.32733402 0.204946211 61.53119889 449.4609123 0.09248911 30 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 33 CAMERON TX 186.4376847 337.1386704 1.041731798 166.0547995 121.2.964203 0.220530218 34 CAMP TX 145.138072 262.4558264	25	BRISCOE TX	25.84609162	46.73795953	0.144416594	14.63585854	106.9091201	0.022061328
27 BROWN TX 40.54259543 73.31391578 0.226534195 44.65284872 326.1712836 0.067307368 28 BURLESON TX 35.38172094 63.39131578 0.206534195 76.94851685 562.0782823 0.115988169 29 BURNET TX 36.67901571 66.3273402 0.204946211 61.53119889 449.4609123 0.092748911 30 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.03493445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 33 CALEGON TX 186.4376847 337.1386704 1.041731798 166.0547995 1212.964203 0.250302318 34 CAMP TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.032302597 35 CARSON TX 66.69696933 124.1766671 0.338569607 15.01630974 10.96.881646 0.02228348 <	26	BROOKS TX	13.51406567	24.43773178	0.075510656	2.950796366	21.55439274	0.004447876
20 BURLESON IX 35.38172094 63.9817209 0.197697498 76.94851665 562.078223 0.115988169 29 BURNET TX 36.67901571 66.32733402 0.204946211 61.53119889 449.4609123 0.092748911 30 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 33 CAMERON TX 186.4376847 337.1386704 1.041731798 166.0547995 1212.964203 0.250302318 34 CAMP TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.032302597 35 CARSON TX 68.66969693 124.1766671 0.33869607 15.01630974 109.6881646 0.04226348 36 CASS TX 45.07683551 61.51344577 <td< td=""><td>27</td><td>BROWN TX</td><td>40.54259543</td><td>73.31391578</td><td>0.226534195</td><td>44.65284872</td><td>326.1712836</td><td>0.067307368</td></td<>	27	BROWN TX	40.54259543	73.31391578	0.226534195	44.65284872	326.1712836	0.067307368
29 BURNET IX 36.67901571 66.32733402 0.204946211 61.53119888 449.4609123 0.092748911 30 CALDWELL TX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 33 CAMERON TX 186.4376847 337.1386704 1.041731798 166.0547995 1212.964203 0.226348 34 CAMP TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.032302597 35 CARSON TX 68.66969693 124.1766671 0.38369607 15.01630974 109.6881646 0.0226348 36 CASS TX 45.07693551 81.51344577 0.251870093 28.01272228 204.6217844 0.042224912 37 CASTRO TX 557.767586 10008.621313 3.116	28	BURLESON TX	35.38172094	63.98141219	0.197697498	76.94851685	562.0782823	0.115988169
Sub_CALDWELL IX 38.51121892 69.64054055 0.215183756 23.15553715 169.1419806 0.034903445 31 CALHOUN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424891 152.1595821 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 186.4376847 337.1386704 1.041731798 166.0547995 121.2964203 0.22002318 34 CAMP TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.032302597 35 CARSON TX 68.66969693 124.1766671 0.38369607 15.01630974 109.6881646 0.0226348 36 CASS TX 45.07693551 81.51344577 0.251870093 28.01272228 204.6217844 0.042224912 37 CASTRO TX 557.767586 1008.621313 3.116559997 <td>29</td> <td>BURNET IX</td> <td>36.67901571</td> <td>66.32733402</td> <td>0.204946211</td> <td>61.53119889</td> <td>449.4609123</td> <td>0.092748911</td>	29	BURNET IX	36.67901571	66.32733402	0.204946211	61.53119889	449.4609123	0.092748911
CALIFOLIN IX 64.14424931 152.1595621 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424931 152.1595621 0.470161061 37.73326874 275.6265065 0.056877155 32 CALLAHAN TX 84.14424891 152.1595621 0.470161061 37.73326874 275.6265065 0.056877155 33 CAMERON TX 186.4376847 337.1386704 1.041731798 166.0547995 121.2964203 0.250302318 34 CAMERON TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.0326348 35 CARSON TX 68.686969693 124.1766671 0.38369607 15.01630974 109.6881646 0.0226348 36 CASS TX 45.07693551 81.51344577 0.251870093 28.0127228 204.6217844 0.042224912 37 CASTRO TX 557.767586 1008.621313 3.116559997 3.492009621 25.50774011 0.005263673 38 CHAMBERS TX 27.1953961 49.17793146 0.151955914	20		38.51121892	69.64054055	0.215183756	23.15553715	169.1419806	0.034903445
Occupation 64:14424031 152:1585021 0.4/0161061 37.73326874 275.5260165 0.05687755 33 CAMERON TX 186:4376847 337.1386704 1.041731798 166.0547995 1212.964203 0.250302318 34 CAMERON TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.0226348 35 CARSON TX 68.6696993 124.1766671 0.38369607 15.01630974 109.6881646 0.0226348 36 CASS TX 45.07693551 81.51344577 0.251870093 28.01272228 204.6217844 0.042224912 37 CASTRO TX 557.767586 1008.621313 3.116559997 3.492009621 25.50774011 0.005263673 38 CHAMBERS TX 27.1953961 49.17793146 0.151955914 170.9415115 1248.659689 0.257668293 39 CHEROKEE TX 252.0449859 455.7775514 1.408316547 39.50568008 288.5732658 0.059548796	21		84.14424891	152,1595821	0.470161061	37.73326874	275.6265065	0.056877155
Construction 106.03/06047 337.1369/04 1.041/31/36 106.054/955 121.2364203 0.250302318 34 CAMP TX 145.138072 262.4558264 0.810967723 21.43008995 156.5382758 0.032302597 35 CARSON TX 68.6696993 124.1766671 0.33369607 15.01630974 109.6881646 0.02226348 36 CASS TX 45.07693551 81.51344577 0.251870093 28.01272228 204.6217844 0.042224912 37 CASTRO TX 557.767586 1008.621313 3.116559997 3.492009621 25.50774011 0.005263673 38 CHAMBERS TX 27.1953961 49.17793146 0.151955914 170.9415115 1248.659689 0.257668293 39 CHEROKEE TX 252.0449859 455.7775514 1.408316547 39.50568008 288.5732658 0.059548796	32		04.14424091	152.1595621	0.470161061	37.73326874	2/5.5255065	0.056877155
CARSON TX Castron TA Construction	37		100.43/004/	337.1366704	0.940097732	100.0547995	1212.964203	0.200302318
CASTRONING 00.0000000000000000000000000000000000	35		143.130072 69.66060602	202.4000204	0.39360607	21.40006995	100.0002700	0.032302397
CASTRO TX 45.0765351 01.51344577 0.251070035 22.01272228 204.5217644 0.042224912 37 CASTRO TX 557.767586 1008.621313 3.116559997 3.492009621 25.50774011 0.005263673 38 CHAMBERS TX 27.1953961 49.17793146 0.151955914 170.9415115 1248.659689 0.257668293 39 CHEROKEE TX 252.0449859 455.7775514 1.408316547 39.50568008 288.5732658 0.059548796	36		45.07603554	124.17000/1	0.36369607	15.01630974	204 624 7844	0.0220340
CHAMBERS TX 27.1953961 49.17793146 0.151955914 170.9415115 1248.659689 0.257668293 39 CHEROKEE TX 252.0449859 455.7775514 1.408316547 39.50568008 288.5732658 0.059548796	37		40.07080001	1009 60104977	2 116550007	20.01272220	204.0217.044	0.042224312
39 CHEROKEE TX 22.1333301 45.17735140 0.13133314 170.3413113 1248.533608 0.237666283 39 CHEROKEE TX 255.7775514 1.408316547 39.68108 288.5732658 0.059548796	38	CHAMBERS TV	27 1053061	/000.021313	0.151055501/	170 0/15/15	1248 659689	0.003203073
	39		252 0449859	455 7775514	1 408316547	39,50568008	288 5732658	0.257500285
		A AL Oberti Charte / of	202.0440000	400.1110014	1.400310347	00.0000000	200.01 02000	0.000040130

Once the fractional county productions of each commodity group and the state-to-county centroidal distances are available, then the utility equations of the calibrated attraction flow distribution model can be applied to compute Texas county-to-state flows. Agricultural truck flows to Alabama from Texas (available from CFS) is used to illustrate the procedure for computing Texas county-to-state truck flows. In essence, the objective is to determine the fraction of the total agricultural truck flows attracted to Alabama from Texas that originates in each Texas county.

The first step is to develop an Excel worksheet that contains the total annual agricultural truck flows to Alabama from Texas (available from CFS), the centroidal distances between Alabama and each of the Texas counties, and the fractional production of agricultural commodities by each Texas county (see Texas County to State Flows on the CD and the screenshot on the opposite page).

The utility equation for agricultural truck flows to Alabama from Texas developed in Step 5 is:

$$V_{Al,Tx}^{Agri} = 1.185 - (0.002 * d_{Al,Tx}) + (0.126 * FP_{Tx}^{Agri})$$

Where,

Tx = Texas is a production state

 d_{ALTx} = Centroidal distance between Alabama and Texas

 FP_{Tx}^{Agri} = Fractional productions in Texas of agricultural commodities

The utility function for agricultural flows to Alabama from each Texas county is assumed to be the same as the utility function for agricultural flows to Alabama from Texas. Consequently, the utility function for agricultural flows to Alabama from county i in Texas is:

$$V_{AIi}^{Agri} = 1.185 - (0.002 * d_{AIi}) + (0.126 * FP_i^{Agri})$$

Where,

i = Texas county

 d_{ALi} = Centroidal distance between Alabama and county *i*

 FP_i^{Agri} = Fractional production of agricultural commodities in county *i*

The agricultural flows to Alabama from each Texas county can thus be calculated using the attraction flow distribution model as follows:

$$T_{Al,i}^{agri} = T_{Al,Tx}^{agri} * \frac{e^{V_{Al,i}^{agri}}}{\sum_{i=1}^{254} e^{V_{Al,i}^{agri}}}$$

Where,

 $T_{Al,Tx}^{agri}$ = Total agricultural truck flows to Alabama from Texas

The required calculations are illustrated in the screenshot on the opposite page.

	-	Calculat	red in Step 6(2)	The formule	a for calculating
Available from		Calculat	to State Controidel	the experience	tial of the utility
the CES		County	to State Centroidal	the exponen	that of the utility
	Texas County to	State Flows.xl. Distance	es	V ^{agri}	
Included in Step I	t Format Tools	Data Window Help	/	$(e^{Al,l})$ is	= EXP((1.185-
Attraction Flow	1.454 LD- 000 L			(0.002*C3)	(0.126*D3)))
Distribution.	1 🖾 🕮 🛅 🗉	-7 • 🕵 Σ • Ż↓	Arial	10 - B (0.002 - C3) + C3)	(0.120*D3)))
	=EXP((1.185-(0.0	102*C3)+(0.126*D3))			
A	В	C /	D	E	F
1 Origin State: Texas	Agriculture			U = 1.185 - (0.002 d) + (0 P)	
2 Destination: Alabam	a <u>21</u>	Alabama-County Cent Dis	t Fractional Productions	exp(U)	County to Alabama
3	ANDERSON IX	5/6.63	0.3/9498331	1.08280705	0.121389445
4	ANDREWS IX	981.66	0.069955667	0.463242045	0.051932332
5		552.39	0.354599548	1.133034626	0.12/0202/1
7		803.42	0.1/1/62034	0.570187347	0.075132195
(0		767.43 954.76	0.440000270	0.494951734	0.00007000
a		852	0.100402101	0.618107947	0.000407100
10			0.303333153	0.8652769	0.003233768
11	BALLEY C	alculated in Sten	0.857578812	0.466011	0.057002007
12	BANDERA		0.179550084	0.5937	0.0522421.05
13	BASTROP 6(b) County –	0.286120715	0.797	0.089405156
14	BAYLOR Pr	oductions for each	0.221769931	0.0	0.076934172
15	BEE TX CO	ommodity group	0.182373545		0.074484139
16	BELL TX	700.4z	0.413281192		0.094036271
17	BEXAR TX	816.39	1 001010000		0.08418986
18	BLANCO TX	797.81			D.075177891
19	BORDEN TX	937.92 The	formula for calculat	ing the Texas county to	D.056755345
20	BOSQUE TX	689.88 Ala	bama truck flows of a	agricultural commoditie	s D.095211744
21	BOWIE TX	505.91 is:		C	D.139154572
22	BRAZORIA TX	664.79			0.10331357
23	BRAZOS TX	652.24	254		D.104479954
24	BREWSTER TX	1120.56	$\nabla V'$	agri	0.03925382
25	BRISCOE TX	933.59	e^{A}	<i>u</i> , <i>i</i>	D.057711914
26	BROOKS TX	933.80 = \$1	В\$2* ЕЗ/ (Д), where	0.057188995
27	BROWN IX	/80.44	i=1		0.079210626
28	BURLESUN IX	678.19	4 .		0.096831952
29	BURNELLTY	772.60	V_{Al}^{agri}		0.080243869
21		763.67	$e^{Ai,i}$ - SUM (F)	$P(\mathbf{F}) = 197 200025$	0.001795342
37			= 50M (E.	$\mathbf{5.E.}_{230} = 187.3222833$	0.000400420 D 077085853
33		970.95 i=	l		0.077505055
34		537.67	0.810967723	1 235952507	0.138558009
35	CARSONLTX	965.65	0.38369607	0.497602211	0.055784321
📕 🔹 🕨 🔪 Sheet1 🔪 alaba	ama (arizona (arka	ansas / california / colorado ,	/ connecticut / delaware /		

Step 6(c): Compute State-to-Texas County Truck Flows

State-to-Texas county truck flows for the nine commodity groups are estimated from the state-to-Texas truck flows reported in the CFS and the utility equations for the production flow distribution model developed in Step 5. In addition, disaggregating the state-to-Texas truck flows to generate state-to-Texas county truck flows using the calibrated production flow distribution model requires the fractional attraction level by each of the Texas counties for each commodity group.

Fractional Attraction Level of Texas Counties

The fractional attraction level of each commodity group destined for each of the Texas counties was calculated from the data captured in the IMPLAN database developed by the Minnesota IMPLAN Group (MIG) Inc. The IMPLAN database provides data on the total annual "Institutional Commodity Demand" in millions of dollars for a total of 528 commodities by each county in Texas (for example, see opposite page for a screenshot of the commodity demand information for Angelina county captured by IMPLAN). These 528 commodities were grouped into the commodity groups listed in Table 1 on page 8 of the manual to compute the total demand in millions of dollars for each commodity group by each of the Texas counties. The county demand for each commodity group by each Texas county was saved in an Excel file (see County Attractions for each commodity group on the CD).

Kicrosoft Excel - Institution Commodity Demand (SA001)										
8	<u>Eile E</u> o	dit <u>V</u> iew Insert F <u>o</u> rmat <u>T</u> ools <u>D</u> ata	<u>W</u> indow <u>H</u> elp					Type a quest		
	-			a micr	- 10 - 72 - 7			ez +.0 .00 z≒ :		
			C	Juner	• 10 • B I		= ± ± \$	70 , .00 , .0 1 ≡ 1		
D	🚔 📕	🔒 🔁 🚑 🖪 🍼 🐰 🖻 🛍 • 🚿	🖍 + 🖂 + 🎑	$\Sigma - \Delta \downarrow Z \downarrow$	🛍 📣 100% 🕞	?				
	Δ1	× f	'ee			, •				
	~ 1		F	F	C C	U	т	т		
1	А		E Insti	tution Com	modity Deman	d	T	J		
2		č Commodity	Households	Federal Gov	State & Local	Capital	Inventory	Foreign Exports		
3	1	Dairy Farm Products	0.009	0.000	0.000	0.000	0.000	0.001		
4	2	Poultry and Eggs	0.226	0.000	0.038	0.000	0.001	0.072		
5	3	Ranch Fed Cattle	0.000	0.000	0.000	0.000	0.019	0.058		
6	4	Range Fed Cattle	0.000	0.000	0.000	0.000	0.006	0.018		
7	5	Cattle Feedlots	0.000	0.000	0.000	0.000	0.000	0.001		
8	6	Sheep- Lambs and Goats	0.000	0.000	0.000	0.000	0.000	0.001		
9	7	Hogs- Pigs and Swine	0.000	0.000	0.000	0.000	0.000	0.000		
10	8	Other Meat Animal Products	0.000	0.000	0.000	0.000	0.000	0.000		
11	9	Miscellaneous Livestock	0.168	0.020	0.003	0.000	0.001	0.133		
12	10	Cotton	0.000	0.000	0.000	0.000	0.000	0.583		
13	11	Food Grains	0.000	0.000	0.000	0.000	0.019	0.774		
14	12	Feed Grains	0.026	0.000	0.012	0.000	0.018	0.326		
15	13	Hay and Pasture	0.013	0.000	0.006	0.000	0.054	0.110		
16	14	Grass Seeds	0.000	0.000	0.007	0.000	0.000	0.000		
17	15	Tobacco	0.000	0.000	0.000	0.000	0.000	0.000		
18	16	Fruits	0.758	0.000	0.016	0.000	0.000	0.017		
19	17	Tree Nuts	0.047	0.000	0.000	0.000	0.000	0.048		
20	18	Vegetables	0.843		0.058			U.119		
21	19	Sugar Crops	0.000					0.000		
22	20	Miscellaneous Crops						0.000		
23	21	Finant Products	0.003	0.000	0.000	0.000	0.000	0.047		
24	22	Creenhouse and Muncory Preducts	0.000		0.000					
25	23	Forestry Products	0.310	0.000	0.074			0.050		
20	25	Commercial Fishing	0.230	0.000	0.000	0.000	0.000	0.014		
28	26	Agricultural- Forestry- Fish	0.075		0.000		0.000	0.020		

However, the county attractions for each commodity group obtained from IMPLAN are in millions of dollars. Since the commodity tonnage attracted are required, the value data were converted to tonnage by applying the value to weight factors for each commodity group listed in Table 4 on page 49 of this manual. In other words, the value-to-weight ratios for each commodity group are applied to the county attractions obtained from IMPLAN to convert the value in millions of dollars to tonnage. Once the total commodity tonnage attracted to each county are calculated, the fractional attractions in each county for each commodity group can be determined. The Excel screenshot on the opposite page illustrates the required calculations for agricultural commodities.

Agricultural demand bbtained from	for ultural 553.	The form calculating th attractions is: agricultural attracted to counties.	nula for ne fractional : C3/Total tonnage all Texas			
	C3*100/C\$258					
	В	C	D		F	G
1 COUNTY ATTRACTION		Agriculture	/		Raw material	
2 0000000	Value (\$ mil)	tons (000)	% tons	Value (\$ mil)	tons (000)	% tons
3 ANDERSON TX	12.2566433	22.16391193	0.246478221	1.1222784	8.197796932	0.087393565
4 ANDREWS TX	5.4873109	9.922804521	0.110348535	2.3635117	17.26451205	0.184050333
5 ANGELINA TX	14.30988097	25.87681912	0.287768349	0.491954173	3.593529385	0.038309237
6 ARANSAS TX	15.0538703	27.22218861	0.3027298	0.3814163	2.786094229	0.029701481
7 ARCHER TX	5.0131151	9.065307595	0.100812568	0.5294558	3.867463842	0.041229547
8 ARMSTRONG TX	3.7372896	6.758209042	0.075156017	0.2538068	1.853957633	0.01976433
9 ATASCOSA TX	9.5289465	17.23136799	0.191624878	2.9653487	21.66069175	0.230916317
10 AUSTIN TX	6.468213458	11.69658853	0.130074255	0.08124508	0.593462965	0.006326681
11 BAILEY TX	16.7381795	30.2679557	0.336600863	0.1280877	0.935629657	0.009974388
12 BANDERA TX	3.4857177	6.30328698	0.070096965	0.2380339	1.738742878	0.01853607
13 BASTROP TX	8.8804588	16.05869584	0.178583943	0.1438001	1.050402484	0.011197938
14 BAYLOR TX	6.5111193	11.77417595	0.130937081	0.1240635	0.906234478	0.009661018
15 BEE TX	7.490634572	13.54545131	0.150634904	1.528031346	11.16166067	0.118990178
16 BELL TX	42.28340612	76.46185555	0.850309376	1.145522345	8.367584698	0.089203607
17 BEXAR TX	235.7497445	426.3105687	4.740872049	25.13714129	183.61681	1.957468303
18 BLANCO TX	1.522828281	2.753758193	0.030623719	0.094015788	0.686747902	0.007321156
19 BORDEN TX	3.52370284	6.371976202	0.070860837	0.000594466	0.004342339	4.6292E-05
20 BOSQUE TX	3.993441481	7.221413167	0.080307171	0.375079965	2.739809824	0.02920806
21 BOWIE TX	15.23601039	27.55155585	0.306392594	0.984722034	7.193002438	0.076681837
22 BRAZORIA TX	40.73673936	73.66498981	0.819206271	2.038914913	14.89346174	0.158773477
23 BRAZOS TX	27.14676983	49.08999969	0.545915172	6.704869002	48.97639885	0.522118581
24 BREWSTER TX	1.864701294	3.371973407	0.037498706	1.479836085	10.80961347	0.115237138
25 BRISCOE TX	7.668473098	13.86703996	0.154211195	0.239113529	1.746629136	0.018620143
26 BROOKS TX	1.729066099	3.126701806	0.034771114	0.064743933	0.472928656	0.005041711
27 BROWN TX	7.622148295	13.78326997	0.153279614	0.704677599	5.147389331	0.054874341
28 BURLESON TX	6.908978277	12.4936316	0.138937932	1.032281282	7.540403816	0.08038535
29 BURNET TX	5.802755802	10.4932293	0.116692058	1.091219984	7.97092757	0.084974998
30 CALDWELL TX	6.072540557	10.981086	0.122117366	0.407201985	2.974448395	0.031709452
31 CALHOUN TX	13.50088024	24.41388831	0.271499534	0.56568552	4.132107524	0.044050812
32 CALLAHAN TX	13.50088024	24.41388831	0.271499534	0.56568552	4.132107524	0.044050812
33 CAMERON TX	68.6914423	124.2159897	1.381368788	10.43765395	76.24290687	0.812796353
34 CAMP TX	3.615297556	6.537608601	0.072702786	0.710057687	5.186688727	0.055293297
35 CARSON TX	10 02174167	18 12249849	0.201534874	0 211307546	1 543517499	0 016454847
Sneet1 (Sneet2)	(Sneet3 /					

Once the fractional county attractions for each commodity group and the state-to-county centroidal distances are available, then the utility equations of the calibrated production flow distribution model can be applied to generate state-to-Texas county flows. Food flows from Alabama to Texas (available from CFS) is used to illustrate the procedure for computing state-to-Texas county truck flows. In essence, the objective is to determine the fraction of the total food truck flows from Alabama to Texas destined for each county in Texas.

The first step is to develop an Excel worksheet that contains the total annual truck flows of food from Alabama to Texas (available from the CFS), the centroidal distances between Alabama and each of the Texas counties, and the fractional attractions of food commodities by each Texas county (see State to Texas County Flows on the CD and the screenshot on the opposite page).

The utility function for truck flows of food commodities from Alabama to Texas developed in Step 5 is:

$$V_{Al,Tx}^{food} = -(0.004 * d_{Al,Tx}) + (0.605 * FA_{Tx}^{food})$$

Where,

Tx = Texas is an attraction state

 $d_{Al,Tx}$ = Centroidal distance between Alabama and Texas

 FA_{Tx}^{food} = Fractional attractions for food commodities in Texas

The utility function for food flows from Alabama to each Texas county is assumed to be same as the utility function for food flows from Alabama to Texas. Consequently, the utility function for food flows from Alabama to county *j* in Texas is:

$$V_{Al,i}^{food} = -(0.004 * d_{Al,i}) + (0.605 * FA_i^{food})$$

Where,

j = Texas county

 $d_{Al,j}$ = Centroidal distance between Alabama and county j

 FA_{i}^{food} = Fractional attractions for food commodities in county *j*

The food flows from Alabama to each Texas county can thus be calculated using the production flow distribution model as follows:

$$T_{Al,j}^{food} = T_{Al,Tx}^{food} * \frac{e^{V_{Al,j}^{food}}}{\sum_{j=1}^{254} e^{V_{Al,j}^{food}}}$$

Where,

 T_{ALTx}^{food} = Total truck flows of food commodities from Alabama to Texas.

The required calculations are illustrated in the screenshot on the opposite page.



Step 6(d): Compute Texas County-to-County Truck Flows

Texas county-to-county truck flows for the nine commodity groups are estimated from the Texas-toTexas truck flows reported in the CFS and the utility equations for the attraction flow distribution and production flow distribution models developed in Step 5. In addition, disaggregating the Texas-to-Texas truck flows using the calibrated attraction flow distribution and production flow distribution models requires the fractional production level by (calculated in Step 6(b)) and the fractional attraction level of (calculated in Step 6(c)) each of the Texas counties for each commodity group, respectively. Once the fractional attractions and productions for each Texas county for each commodity group, and the county-to-county centroidal distances (calculated in Step 6(a)) are available, then the attraction flow distribution and production flow distribution flow distribution flow distribution flow distribution flow distributions.

Texas County-to-Texas Flows

It is first necessary to determine the total Texas-to-Texas flows that originate in each Texas County. Intra-state truck flows of food commodities (available from CFS) are used to illustrate the procedure for computing Texas county-to-county truck flows.

The first step is to develop an Excel worksheet that contains the total annual intra-state truck flows of food commodities in Texas (available from the CFS), the centroidal distances between Texas and each of the Texas counties, and the fractional production of food commodities by each Texas county.

The utility equation for truck flows of food commodities to attraction state j from Texas developed in Step 5 is:

$$V_{i,Tx}^{food} = -(0.003 * d_{i,Tx}) + (0.504 * FP_{Tx}^{food})$$

Where,

Tx = Texas is a production state

 $d_{j,Tx}$ = Centroidal distance between state j and Texas

 FP_{Tx}^{food} = Fractional productions in Texas of food commodities

Note, however, that in this case the attraction state is also Texas. The utility function for truck flows of food commodities to Texas from each county in Texas is thus:

$$V_{Tx,i}^{food} = -(0.003 * d_{Tx,i}) + (0.504 * FP_i^{food})$$

Where,

 $d_{T_{x,i}}$ = Centroidal distance between Texas and county *i*

 FP_i^{food} = Fractional productions of food commodities in county *i*

The intra-state food flows destined for Texas from each Texas county can thus be calculated using the attraction flow distribution model as follows:

$$T_{Tx,i}^{food} = T_{Tx,Tx}^{food} * \frac{e^{V_{Tx,i}^{food}}}{\sum_{i=1}^{254} e^{V_{Tx,i}^{food}}}$$

Where,

 T_{T_x,T_x}^{food} = Total intra-state truck flows of food commodities

The required calculations are illustrated in the screenshot on the next page.



Texas County-to-County Flows

Once the total truck flows destined for Texas that originate in each Texas County have been calculated, the Texas county-to-county truck flows can be computed for each of the nine commodity groups. Intra-state food flows is used to illustrate the procedure for computing Texas county-to-county truck flows.

The first step is to develop an Excel worksheet that contains the total annual truck flows of food commodities from each county in Texas that are destined for Texas, the inter-county centroidal distances (developed in Step 6(a)), and the fractional attractions of food commodities by each Texas county (see Intercounty Food on the CD and the screenshot on the opposite page).

The utility function for truck flows of food commodities from county i to county j in Texas developed in Step 5 is:

$$V_{i,j}^{food} = -(0.004*d_{i,j}) + (0.605*FA_j^{food})$$

Where,

 $d_{i,i}$ = Centroidal distance between county *i* and county *j*

 FA_{i}^{food} = Fractional attractions for food commodities in county j

The food flows from county i to county j in Texas can thus be calculated using the production flow distribution model as follows:

$$T_{i,j}^{food} = T_{i,Tx}^{food} * \frac{e^{V_{i,j}^{food}}}{\sum_{j=1}^{254} e^{V_{i,j}^{food}}}$$

Where,

 T_{i,T_x}^{food} = Total truck flows of food commodities from county *i* destined for Texas.

The required calculations for calculating the food commodity flows from Anderson county to each county in Texas are illustrated in the screenshot on the opposite page.

				Calc	culated in Step 6	5(a) The formula	for colculating
				Cou	nty-to-County		
		1		Cou	inty-to-County	the exponent	ial of the utility
A	vailable from			Cen	troidal Distances	V: food	
S	tep 6 Texas	tercounty Food.	xls			$(e'^{i,j})$ i	s = FXP((-
C	ounty to State	Format Tools D)ata Window Help				(0.605*E3)
	James to Blate					(0.004^* D3)	+ (0.605* E3)
Г	lows	B, 143 🖪 🖬 1	-) • 😸 Σ • Ż↓		• 10 • B 1		
		Jounty					
	A	В	C	D	E		G
1	County County	to exas Food	County	Intercounty Cent E	Dist Fractional Attractions	Exp(U)=Exp(0.605A))	Intercounty Flows
2	ANDERSON IX 5.	491127857	ANDERSON TX	U	212846965	4.137431231	0.00/138247
3			ANDREWS IX	447.71	0.051373887	0.000005170	2/159E-05
4				220.0	0.397225227	0.000235172	0107959
0				320.0		0.295627521	
7					0.008062557	0.331343422	0487E-05
8			TASC Calcu	lated in Step	p 0.00000007	0.32886505	99713E-05
9				Count	v 0.1078211	0.52000303	6 85923E-05
10			BALL	count	0.039474542	0.138124766	1.67881E-05
11			BANDE Attra	ctions for each	n 0.070427928	0.30158267	3.66553E-05
12			BASTE com	nodity group	0.257030773	0.58099310	7.06157E-05
13			BAYLOR IX	267.29	0.018899444	0.3472446	4.22052E-05
14			BEE TX	303.25	0.108502736	0.31747	3.85869E-05
15			BELL TX	141.94	1.087894256	1.094	0.000133045
16			BEXAR TX	262.25	6.567603589	18.6	0.002263502
17			BLANCO TX	230.13			E-05
18			BORDEN TX	407.93	The formula for calc	ulating truck flows of foo	od = -05
19			BOSQUE TX	137.33	commodities from A	nderson county to each 7	E-05
20			BOWE IX	157.43	commodities nom A	nucrson county to each I	CAAS =-U5
21				197.57 1	s:		1//8
22				F66 57			1093 E-05
21			BRISCOE TX	425.16	254	TZ food	E-05
25			BROOKS TX	429.70		Anderson, j	E-05
26			BROWN TX	227.89 =	= \$B\$2* F3 / (🚄 ⁶) where	E-05
27			BURLESON TX	131.45	<i>↓↓</i>),	-05
28			BURNET TX	206.46	J^{-1}		E-05
29			CALDWELL TX	214.65	254 food		E-05
30			CALHOUN TX	280.49	V Anderson, i		E-05
31			CALLAHAN TX	251.03) e	$(\mathbf{F7} \cdot \mathbf{F755}) = 45179$	46033
32			CAMERON TX	474.27	= $=$ 3	$(\mathbf{F} 2 \cdot \mathbf{F} 2 \cdot 5 3) = 431/8$	-40733 E-05
33			CAMP TX	108.82	J=1		E-05
34			CARSON TX	457.22	0.004000001	0.100000420	