Accessibility, Income, and Person Trip Generation: Multilevel Model of Activity at Food Retail Establishments in Portland, Oregon

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Abstract

In the past decade, the methods for estimating multimodal transportation impacts of urban land use development have improved substantially. One assumption commonly made in these new methods is that overall person-trip rates at similarly-sized establishments of the same land use do not vary across a region. This is an assumption of convenience to permit the adjustment of ITE Trip Generation vehicle trip rates for use in different urban environments. However, this assumption is inconsistent with theories of urban economics, which recognize that businesses pay a premium to locate in areas with high levels of accessibility to attract more customers. In addition, most transportation impact analyses have ignored income effects, even though socio-economics are a proven driver of travel behavior. To test this assumption and understand the effects of accessibility and income on levels of activity at the establishment level, we examine transaction counts for 97 grocery and convenience markets in Portland, Oregon. In a multilevel negative binomial regression, we test the relationship of regional accessibility, local accessibility, and income on weekly and daily transaction rates. While there was not enough evidence to suggest a significant relationship between accessibility and transaction rates, the results indicated a significant relationship with median income of the surrounding area. The implications point to the need to consider area-wide socio-demographics in site-level transportation impact analysis. The study also provides some important discussion about the use of transaction as a proxy for person-trip rates.

Using Transaction Data for Transportation Impact Analyses

As mentioned previously, there are distinct differences between "transaction counts" and "person-trip counts." A person-trip count, as used in ITE's recommended practice, is a general term that is often used interchangeably with the more apt term "person trip end" count. We use them interchangeably in this manuscript for simplicity. Person-trip counts are defined as the number of people entering or leaving the study development within a given time period. If 30 people enter and exit a 2,500-square-foot convenience market within a PM peak hour (5-6PM, for example), the person trip (end) count is 60 person trips (30 entering and 30 exiting). These counts are often expressed as person-trip rates controlling for the size of the development; in the case of convenience markets and grocery stores, this is typically square footage of gross leasable area (GFA) in thousands of square feet (SQFT). For the earlier example, the person-trip rate would be 24 person trip (ends) counts per 1,000 SQFT of GFA.

Transaction counts—aggregated by any length of time—reflect the number of sales transactions within each time period the business is open. Similar with person-trip rates, transaction rates control for the size of each establishment—in this case, for parity, we also use GFA in 1,000 SQFT increments. For this purpose, we use transaction data as a means for understanding relative variation in overall levels of activity, not as a way of estimating overall trip rates. To consider this, one must understand the turnover of activity—the transaction is, after all, at the end of the activity—as well as the relative group size for every transaction estimates. In this initial analysis, we assume that all arrivals occur within the same day and week from which the transaction occurred. As we previously identified that average vehicle occupancy, a proxy for group size of automobile trips, considered at the trip end does not vary across urban context within a region for retail establishments, we assume that this holds for relative measures of accessibility.

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TABLE Description of Accessibility-Related Environmental Measures

Measure	Description	Variables/Source
* Regional Accessibility *[index: (0,1)]*	Jobs accessible within a 45 minute drive, weighted by a travel time decay function and normalized by the regional total and maximum accessibility value at a block-group level (Regional Centrality Index)	2010 SLDB; Variables: D5cri
* Local Accessibility *[people per acre]*	Sum of gross population and employment on unprotected land per acre at a block-group level	2010 SLDB; Variables: D1b + D1c
* Median Income *[2014 US Dollars]*	Median household income at a block-group level	2014 ACS (5-year) Variables: B19013
Distance to the CBD *[miles]*	Euclidean distance between the establishment address and the center of the central business district (CBD)	Calculated **
Competition *[count of establishments]*	Number of similar establishments within ½ mile Euclidean distance of the establishment address	2010 ESRI Business Analyst; Variable: NAICS_EXT***
Land Value *[2016 US dollars per square foot of land]*	Average real market value of land (no building) per square foot for commercial land within a ½ mile Euclidean buffer of the establishment address	2015 RLIS, Taxlot layer; Variables: Landval; Events where Prop_code: 200-292 for Commercial Land

NOTES:
CBD: Central business district
SLDB: Smart Location Database - https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
RLIS: Regional Land Information System - http://rlisdiscovery.oregonmetro.gov/
* Used in the subsequent analysis.
** Portland's metropolitan CBD was estimated to be Pioneer Square.
*** 6-digit NAICS code categories considered include: 445110, supermarkets and other grocery (except convenience) stores; 445120, convenience stores; 445210, meat markets; 445220, fish and seafood markets; 445230, fruit and vegetables markets; 445291, baked goods stores; 445292, confectionery and nut stores; 445299, all other specialty food stores; and 445310, beer, wine, and liquor stores.

TABLE Negative Binomial Multilevel Model with Repeated Measures: Estimating Weekly and Daily Transaction Counts (per 1,000 SQFT of GFA)

	Dependent Variables:	Weekly Transactions		Daily Transactions by Day of the Week											
				Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
	Independent Variables:	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value
1	Regional Accessibility	-0.05	0.75	0.01	0.98	-0.04	0.80	-0.02	0.91	-0.01	0.93	0.01	0.97	-0.13	0.34	-0.13	0.40
2	Local Accessibility	0.00	0.75	0.00	0.41	0.00	0.36	0.00	0.48	0.00	0.32	0.00	0.94	-0.00	0.37	-0.00	0.19
3	Median Income ($10,000)	-0.05	0.00	-0.04	0.01	-0.04	0.01	-0.04	0.01	-0.04	0.01	-0.05	0.00	-0.05	0.00	-0.05	0.00
4	GFA (1,000 SQFT.)	-0.32	0.00	-0.29	0.00	-0.34	0.00	-0.30	0.00	-0.31	0.00	-0.32	0.00	-0.35	0.00	-0.36	0.00
5	Grocery Store ±	-1.34	0.02	-1.16	0.05	-1.42	0.01	-1.05	0.07	-1.46	0.01	-1.39	0.01	-1.43	0.01	-1.53	0.01
	Interactions with Grocery ±																
6	Regional Accessibility	0.48	0.42	0.51	0.42	0.53	0.39	0.30	0.63	0.47	0.45	0.33	0.59	0.49	0.36	0.75	0.23
7	Local Accessibility	-0.0	0.74	-0.01	0.60	-0.01	0.71	-0.00	0.82	-0.00	0.85	-0.0	0.87	-0.00	0.85	-0.01	0.62
8	Median Income ($10,000)	0.05	0.09	0.04	0.19	0.05	0.15	0.05	0.17	0.05	0.17	0.06	0.09	0.06	0.03	0.07	0.04
9	GFA (1,000 SQFT.)	0.29	0.00	0.25	0.00	0.30	0.00	0.27	0.00	0.28	0.00	0.28	0.00	0.3	0.00	0.33	0.00
0	(Intercept)	8.53	0.00	6.43	0.00	6.59	0.00	6.53	0.00	6.57	0.00	6.65	0.00	6.70	0.00	6.65	0.00
	Observations	147		160		147		147		147		147		147		160	
	Log Likelihood	-1,243		-1,038		-952		-967		-969		-972		-987		-1,053	
	AIC	2,511		2,100		1,929		1,959		1,963		1,968		1,999		2,131	
	Null Model AIC	2,651		2,235		2,069		2,089		2,105		2,115		2,138		2,246	
	Deviance	2,487		2,076		1,905		1,935		1,939		1,944		1,976		2,107	

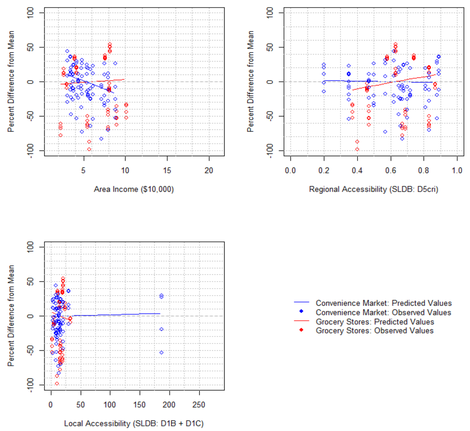
NOTES:
An offset was used to normalize transactions by the exposure, measured in establishment level GFA in 1,000 SQFT and transformed using the natural log.
± Dummy Variable
AIC: Akaike Information Criterion
GFA: Gross Floor Area
SQFT: Square Footage

TABLE Descriptive Statistics of Dependent and Independent Variables, Including Regional Comparison

	Convenience Market				Grocery Stores			
	Mean	St. Dev.	N	Range	Mean	St. Dev.	N	Range
Observed Data								
Locations	---	---	84	---	---	---	13	---
Weekly Transaction *[Counts]*	4,460	1,062	92	2,596 -8,335	16,785	3,903	63	10,088 - 23,930
Daily Transaction *[Counts, all days]*	637	164	644	325 -1,395	2,396	580	467	1,203 - 3,889
Gross Floor Area *[1,000 SQFT]*	2.5	0.3	84	2.1 - 4.6	33.0	9.2	13	17.2 - 50.0
Contextual Information								
Observed Locations								
Regional Accessibility *[Index (0,1)]*	0.62	0.19	84	0.20 - 0.89	0.63	0.16	13	0.37 - 0.87
Local Accessibility *[People per acre]*	21.6	37.6	84	3.6 - 187.0	16.1	7.6	13	2.0 - 32.6
Median Income *[2014 $10,000 US Dollars]*	5.31	1.68	84	3.10 - 8.81	6.00	2.53	13	2.30 - 10.15
Portland Region								
	Mean		St. Dev.		N		Range	
Regional Accessibility *[Index (0,1)]*	0.50		0.21		1319 *		0 - 1	
Local Accessibility *[People per acre]*	12.7		18.0		1319 *		0.01 - 280.81	
Median Income *[2014 $10,000 US Dollars]*	63.70		26015		1319 *		10.96 - 209.93	

NOTES:
± Collected from the Portland Metropolitan Area using the same variables as described in Table 1.
* Calculated by block groups in the Portland, Oregon area.
SQFT: Square footage
St.Dev.: Standard deviation

FIGURE Predicted relationships and observed values for (top left) income, (top right) regional accessibility, and (bottom left) local accessibility.



Findings

To further investigate the relationship identified between accessibility measures and income, we predict weekly transaction rates for the range of incomes observed in our sample and measure the percent difference of this predicted value from the predicted mean value—all else equal. We then compare this relationship visually with the percent difference between the observed weekly transaction rates and the mean observed transaction rate (see FIGURE, top right). In these figures, the convenience markets are show with a blue line (predicted relationship) and blue dots (observed values), and grocery stores, red. We then examine the same relationships with predicted values and observed locations for regional accessibility and local accessibility (see FIGURE, top right and bottom left, respectively). The categorical lumping of data along the x-axis is a result of two artifacts of the data: the repeated measures at grocery stores (blue dots), and the grouping of convenience markets to mask locational information (red dots).

For income predicted along the range of observed incomes in our sample (approximately $23,000-$101,500), the variation of predicted values ranges from -15% and 10% (convenience market) and -3% to 3% (grocery stores) around the mean predicted value. Taken at the average daily transaction rate (approximately 82 transactions per 1,000 SQFT), a 3% difference for grocery stores may result in a variation in approximately 2 transactions per 1,000 SQFT. But for convenience markets, with an average daily transaction rate of about 250 transactions per 1,000 SQFT, a 10-15% difference in rate variation suggests between 25 and 37 additional transactions per 1,000 SQFT per day.