

GEORGIA DOT RESEARCH PROJECT 24-12

Final Report

**ECONOMIC ANALYSIS OF
RCUT ACCESS IMPACTS IN GEORGIA**



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16. Abstract: Restricted Crossing U-Turn (RCUT) intersections are an established roadway design that state transportation agencies use to improve traffic operations. When the Georgia Department of Transportation (GDOT) proposes an RCUT, however, local communities and business owners frequently express concern that changing how customers enter and exit their properties will reduce revenue and harm local economic health. Because private sales tax data is strictly confidential under Georgia law, direct sales figures cannot be used to measure these effects. To overcome this lack of direct data, this study analyzes the economic impact of RCUT installations on nearby businesses at eight locations in Georgia using four alternative methods: 1) a property value analysis to determine whether the access changes affected adjacent real estate markets; 2) a satellite nighttime lights analysis using Visible Infrared Imaging Radiometer Suite (VIIRS) radiance as a proxy for commercial activity; 3) a traffic detour model that estimates how added out-of-direction travel distance affects the probability of an impulsive customer stop; and 4) a direct survey of local business owners and residents to capture their perceptions and experiences. The combined results show that RCUT installations do not cause significant economic harm to most commercial businesses, although localized negative effects can occur at industrial or residential corridors where the required detour is long. Based on these findings, this study provides GDOT with a practical screening tool, proactive community outreach strategies, and geometric design guidance to balance intersection performance with local economic health.			
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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380 (Revised March 2003)

LIST OF ABBREVIATIONS

<i>AADT</i>	average annual daily traffic
<i>CI</i>	confidence interval
<i>CSV</i>	comma-separated values
<i>DCE</i>	discrete choice experiment
<i>DiD</i>	difference-in-differences
<i>DNB</i>	day/night band (VIIRS sensor band)
<i>DOT</i>	department of transportation
<i>DOTD</i>	Louisiana Department of Transportation and Development
<i>FHWA</i>	Federal Highway Administration
<i>GDOR</i>	Georgia Department of Revenue
<i>GDOT</i>	Georgia Department of Transportation
<i>GDP</i>	gross domestic product
<i>GEE</i>	Google Earth Engine
<i>GIS</i>	geographic information system
<i>GPS</i>	global positioning system
<i>HEP</i>	high-energy particles
<i>IRB</i>	Institutional Review Board
<i>ITE</i>	Institute of Transportation Engineers
<i>KABCO</i>	crash injury severity classification scale
<i>LADOTD</i>	Louisiana Department of Transportation and Development
<i>LSU</i>	Louisiana State University
<i>MIT</i>	modified interrupted time series
<i>NCDOT</i>	North Carolina Department of Transportation
<i>NOAA</i>	National Oceanic and Atmospheric Administration
<i>NTL</i>	nighttime light
<i>O.C.G.A.</i>	Official Code of Georgia Annotated
<i>OSM</i>	OpenStreetMap
<i>PDO</i>	property damage only
<i>PDP</i>	Plan Development Process
<i>QR</i>	quick response (code)
<i>RCI</i>	reduced conflict intersection
<i>RCUT</i>	restricted crossing U-turn
<i>ROW</i>	right of way
<i>RP</i>	research project
<i>SR</i>	state route
<i>TADA</i>	Traffic Analysis and Data Application
<i>TGM</i>	Trip Generation Manual
<i>TTI</i>	Texas Transportation Institute
<i>TxDOT</i>	Texas Department of Transportation
<i>US</i>	United States (route designation)
<i>VIIRS</i>	Visible Infrared Imaging Radiometer Suite
<i>WisDOT</i>	Wisconsin Department of Transportation

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
CHAPTER 1. INTRODUCTION	4
1.1 PROJECT BACKGROUND.....	4
1.2 RESEARCH PROBLEMS.....	4
1.3 RESEARCH OBJECTIVES.....	6
1.4 REPORT ORGANIZATION.....	8
CHAPTER 2. LITERATURE REVIEW	10
2.1 OBJECTIVES OF THE LITERATURE REVIEW	10
2.2 BENEFITS OF RESTRICTED CROSSING U-TURNS (RCUTS)	11
Traffic Flow and Efficiency.....	11
Safety Improvements: Crash and Severity Reduction	12
Cost-Effectiveness and Reduced Maintenance.....	13
Perceptions of Local Businesses.....	13
2.3 STATE DEPARTMENT OF TRANSPORTATION APPROACHES TO	
ECONOMIC IMPACT	14
Texas Department of Transportation Study	15
Louisiana Department of Transportation and Development Study.....	18
North Carolina Department of Transportation Study	21
Synthesis of State DOT Approaches	24
Economic Proxies	26
2.4 GAPS IN THE EXISTING RESEARCH	28
Broader economic factors insufficiently controlled	29
Competitive dynamics and spatial redistribution	29
Generalizability to other states and contexts.....	29
Customer behavior and shopping patterns over time	30
Limited sample size in prior studies.....	30
Complex transportation-land use relationships.....	30
Remote sensing spatial resolution limitations	30
Survey Bias	31
CHAPTER 3. ECONOMIC ANALYSIS OF RCUT IN GEORGIA	32
3.1 OBJECTIVE OF THIS CHAPTER.....	32
3.2 RCUT AND CONTROL SITE SELECTION	33
Candidate Inventory and Screening.....	34
3.3 DATA COLLECTION	37

Absence of Business-Level Sales Tax Data	37
Property Value Valuation Data Collection	39
Remote Sensing Data Collection	40
3.4 ECONOMIC IMPACT ANALYSIS	42
Property Valuation Analysis	42
VIIRS Nighttime Lights	46
Modified Interrupted Time Series (MITS)	48
Differences Between the DiD and MITS Approaches	51
Cross-Method Triangulation	52
CHAPTER 4. ACCESSIBILITY STUDY	54
4.1 ACCESSIBILITY ANALYSIS	54
Spatial Framework	54
Route Scenarios	55
Data Collection	56
CHAPTER 5. QUALITATIVE SURVEY	67
5.1 SURVEY DESIGN	68
5.2 QUESTION ORDERING AND THE PRIMING CONCERN	69
5.3 BLOCK AND PATH SUMMARY	70
Sample and data processing	70
CHAPTER 6. ANALYSIS RESULTS	74
6.1 PROPERTY VALUATION ANALYSIS	74
Primary results	74
Residential and commercial decomposition	77
Secondary RCUT pairs	78
Interpretation	79
Buffer sensitivity	80
6.2 REMOTE SENSING (VIIRS NIGHTTIME LIGHTS) ANALYSIS	81
Primary results	81
Cross method agreement	85
Interpretation	87
Matched buffer cross method read at 1640ft	87
6.3 ACCESSIBILITY RESULTS	90
Decay Model Applied to Primary Study Pairs	90
Directional Asymmetry and Quadrant Effects	91
U-turn crossover Proximity	92
Interpretation	93
6.4 SURVEY RESULTS	94

Business findings	94
Resident and patron findings	108
Cross cutting findings	113
CHAPTER 7. IMPLEMENTATION PLAN	115
7.1 RCUT DECISION MAKING TOOL	116
7.2 ENHANCEMENT METHODS	117
Method 1) RCUT Signalization Enhancement	117
Method 2) High Impulse Business U-Turn Placement	117
Method 3) Compensatory Access and Exits	117
Method 4) Wayfinding Signage	118
Method 5) Pedestrian Infrastructure	118
criteria and implementation actions	119
7.3 COMMUNITY AND BUSINESS OUTREACH	120
Pre-construction engagement and perception gap communication.	120
Construction Period Communication	122
Post-installation Period	123
7.4 GDOT IMPLEMENTATION ROADMAP	123
Tool Deployment	124
Staff Training	124
Pilot Application	125
Long-Term Calibration	125
CHAPTER 8. CONCLUSIONS	127
8.1 RESEARCH CONTRIBUTIONS	127
8.2 KEY FINDINGS	128
8.3 LIMITATIONS	130
Analysis Limitations	130
Data Availability Limitations	130
Methodological Limitations	131
Sample Size and Statistical Power	133
Temporal Scope and External Conditions	133
Generalizability	134
8.4 RECOMMENDATIONS FOR FUTURE RESEARCH	135
APPENDIX	138
APPENDIX A: SITE INVENTORY	138
APPENDIX B: SURVEY	143
APPENDIX C: GUIDELINE RCUT VISUALS	157
APPENDIX D: SAFETY ANALYSIS	159

CRASH ANALYSIS	159
Method and windows	160
Treatment site results	160
Pair level difference-in-differences.....	161
Crash-type shifts	163
Consistency with the published RCUT literature	164
References:.....	165

LIST OF FIGURES

Figure 1: Diagram. Four Quadrant Areas of an RCUT Intersection.....	54
Figure 2: Diagram. Georgia Department of Transportation Signing and Marking Design Guidelines.....	57
Figure 3: Screenshot. Pair 90 Post RCUT Northbound detour (0.62 miles).....	59
Figure 4: Screenshot. Pair 90 Post RCUT Southbound detour (0.25 miles).....	59
Figure 8: Plot. Forest plot of property value DiD estimates, primary (top block) and secondary (bottom block) pairs. Whiskers show 95% confidence intervals.	77
Figure 9: Plot. Pair level DiD for residential property value (red circles) and commercial (blue squares) parcels, pooled and by pair. Whiskers are 95% CI.	78
Table 10: Secondary property value DiD results for adjacent RCUT parcels.	79
Figure 11: Plot. Property DiD across three matched buffers.	80
Figure 12: Plot. Buffer dilution of the MITS coefficient.	83
Figure 13: Plots. Treatment and control monthly radiance time series per pair (330ft buffer), with the installation year located in the middle marked by a gray border.....	83
Figure 14: Plots. Seasonal decomposition.	84
Figure 15: Plots. Monthly radiance heatmap for treatment and control sites, primary pairs. Rows are months, columns are pairs. The dashed horizontal line marks each pair's installation month.	84
Figure 16: Plots. Treatment minus control radiance heatmap at 0ft, 330ft, and 1640ft buffers. Blue cells are treatment below control, red cells are above.	85
Figure 17: Plot. Cross method scatter. Horizontal axis: pair level property DiD (%). Vertical axis: VIIRS MITS coefficient at 330ft.	86
Figure 18: Plots. Aligned trend lines: annual treatment minus control property value gap (blue) and VIIRS treatment minus control radiance gap (orange).	87
Figure 19: Plot. Cross-Method Scatter Plot at 1640ft Buffer. Property Value DiD (X) vs VIIRS MITS (Y).	89
Figure 20: Plots. Matched-Buffer Coefficient at 1640ft. Property Value (Left) and VIIRS MITS (Right) by Pair.	90
Figure 21: Plot. Distribution of survey responses by respondent type	95
Figure 22: Plot. Frequency of visits reported by survey respondents, showing the number of respondents who use the corridor daily, several times a week, once a week, or a few times a month	96
Figure 23: Plot. Daily customer volume reported by surveyed businesses	96
Figure 24: Plot. Primary travel mode reported by Business Respondents.....	97
Figure 25: Plot. Business reported revenue change in the past year.....	98
Figure 26: Plot. Business reported revenue change in the past year, including unsure/no responses.....	98
Figure 27: Plot. Business reported customer volume change in the past year, respondents who were unsure were not included in this figure.....	99
Figure 28: Plot. Relationship between perceived revenue change and customer volume change among surveyed businesses. Cells on the diagonal indicate respondents whose revenue and	

volume perception track together.	100
Figure 29: Plot. Business perception of vehicle access ease for customers.....	101
Figure 30: Plot. Business reported congestion change	101
Figure 31: Plot. Business perceived traffic safety near the establishment.....	103
Figure 32: Plot. Theme coding of business open-ended recommendations.....	104
Figure 33: Plot. Summary of all cross-tabulation tests ranked by p-value	105
Figure 34: Plot. Wilson 95 percent confidence interval forest plot for the headline directional items	107
Figure 35: Plot. Primary mode of transportation reported by resident and patron respondents .	108
Figure 36: Plot. Resident familiarity with the area	109
Figure 37: Plot. Resident reported congestion change.....	110
Figure 38: Plot. Resident perceived safety along the RCUT corridor	111
Figure 39: Plot. Theme coding of resident safety perception responses.....	112
Figure 40: Diagram. Minor Road Constrained Within Commercial Plazas, and NW, SE, SW, and SE Quadrants	157
Figure 41: Diagram. Minor Road Continues as a Live-Through-Street, it is not constrained or end within two commercial plazas	157
Figure 42: Diagram. U-turn crossover Placement Serves the Opposite Quadrant of the Intersection	158
Figure 43: Diagram. Shorter distance to U-turn to offset to Serve the Opposite Quadrant.....	158
Figure 44: Diagram. Wayfinding U-turn signal placement before the U-turn crossover. RCUT maneuver signage placed on the right-side of the minor road.....	158
Figure 5: Plot. Treatment site percent change in yearly crash rate, total crashes (blue) and injury (red)	161
Figure 6: Plots. Forest plot of per pair DiD in yearly crash rates. Left panel: total crashes per year. Right panel: injury crashes per year.	162

LIST OF TABLES

Table 1: Severity Reductions RCUT vs Conventional Intersection Comparison.....	12
Table 2: Summarizes the methodology of three key DOT-sponsored economic impact studies reviewed.	25
Table 3: Site Selection Criteria	37
Table 4: Data Sample of County-Level Gas Station Sales Tax Receipts Obtained from the Georgia Department of Revenue	38
Table 5: Vehicle Movement Restriction Under RCUT Configuration	55
Table 6: Pass-By Trip Rates by Business Type and ITE Land Use Codes.....	62
Table 7: Pass-By Trip Exposure by Business Type.....	63
Table 8: Pass-By Exposure by Travel Direction and Quadrant.....	65
Table 9: ITE vs. Tier-Fixed Pass-by Probability Comparison by Quadrant.....	66
Table 10: Survey Instrument Structure and Routing by Respondent Path	69
Table 16: DiD Estimates for Property Values by Site Pair and Land Use.	74
Table 17: Pre-Treatment Parallel Trends Check for RCUT Treatment and Control Site Pairs....	76
Table 18: Coordinate-Matched Buffer Sensitivity Results for Property Value DiD (Site Pair and Buffer Radius)	81
Table 19: VIIRS MITS results by pair and buffer	82
Table 20: Matched-Buffer Cross-Method Comparison of Property Value DiD and VIIRS MITS Results (1640ft)	89
Table 21: Decay model results for the four primary study pairs by direction of approach	90
Table 22: Accessibility loss comparison across primary study pairs, with cross-reference to property value DiD and VIIRS MITS outcomes	91
Table 23: Recovery in accessibility loss if a U-turn crossover were placed at 0.20 miles from the intersection, sorted by recovery magnitude.....	92
Table 24: Wilson 95 percent confidence intervals for headline percent estimates	106
Table 25: GDOT RCUT Implementation Roadmap Components.....	126
Table 26: Treatment-Control Site Inventory.....	138
Table 27: RCUT Matching Criteria	139
Table 28: RCUT Census Classification	139
Table 29: RCUT Minor Road AADT (Based on Availability).....	140
Table 30: RCUT pre-post AADT and Percent Change	141
Table 31: RCUT Frontage and Visible Businesses.....	142
Table 32: RCUT Zoning Stratification	142
Table 11: Pre-Post Crash Counts for Matched Treatment and Control Site Pairs	159
Table 12: Treatment Site Pre-Post, Yearly Means and Injury Totals	160
Table 13: Pair level DiD in Yearly Crash Rates	162
Table 14: Treatment site percent change in yearly crash rate.....	163
Table 15: Manner of crash counts at the eight treatment sites, pre vs post installation, aggregated across the symmetric per-pair windows.	164

EXECUTIVE SUMMARY

The Georgia Department of Transportation (GDOT) engaged the Georgia Institute of Technology to evaluate the economic impact of Restricted Crossing U-Turn (RCUT) intersections on adjacent businesses, with the goal of producing decision-making guidance for future RCUT siting in Georgia. This report documents the methodology, findings, and recommendations of Research Project RP 24-12. Because Georgia confidentiality law (O.C.G.A. § 48-2-15) precludes researcher access to business-level sales tax data, this study adopted a multi-proxy strategy that measures RCUT economic effects four different ways, so that no finding rests on any single data source:

1. **Property values.** This study compared how assessed property values near each RCUT changed before and after construction, against a similar comparison corridor without an RCUT (a before-and-after comparison known as a difference-in-differences, or DiD, analysis).
2. **Nighttime satellite light.** Because brighter nighttime lighting tracks commercial activity, this study used satellite nighttime-light imagery (VIIRS) as an independent proxy for business activity around each site.
3. **Accessibility.** This study modeled how much harder an RCUT makes it for a passing driver to reach a roadside business on impulse, and how that difficulty changes with U-turn placement.

4. **Stakeholder survey.** This study surveyed business owners, employees, residents, and patrons about their experience of each corridor after the RCUT was built.

The analysis distinguishes two tiers of study sites. Four primary pairs, namely Blairsville (63), Cedartown (79), Alto (88), and Warner Robins (90), have full property valuation coverage and supported the property-value, nighttime-light, and accessibility analyses that carry the study's economic and accessibility conclusions. Four secondary pairs (14, 53, 71, 93) served as robustness checks; their limited parcel samples did not support independent economic conclusions and are reported as supporting evidence only. Crash records from all eight pairs support the safety analysis presented in **Appendix D**.

Economic findings. Across the four primary pairs, the pooled property-value DiD estimate is statistically indistinguishable from zero at the corridor level, with three of four pairs returning null results. The exception is Pair 88 (Alto), which shows a statistically significant 24.0% decline in adjacent assessed property values ($p = 0.013$), corroborated by a significant decline in nighttime-light activity at the same site ($p = 0.004$). Under verified commercial-zoning classification, the pooled commercial property-value estimate is positive and significant at +32.5% ($p < 0.001$), driven principally by Pair 90 (Warner Robins), which shows a verified-zoning commercial gain of +39.8% ($p = 0.044$). RCUT economic outcomes are mixed by land-use context: commercial-dominated corridors show null to positive effects, while the light-industrial corridor with the longest minor-road detours in the sample shows a localized negative effect.

Safety findings. The crash analysis, reported separately from the economic analysis in **Appendix D**, found reductions or no change in injury crashes at seven of the eight treatment sites. The one exception, Pair 14, rests on an injury sample too small to interpret.

Accessibility findings. An accessibility model applied to the primary pairs quantifies the loss in the likelihood that a passing driver stops at a roadside business, and identifies the distance to the nearest U-turn crossover as the single largest design lever for mitigation. Modeled losses reach up to 76.3% under current configurations and converge toward approximately 50% under a 0.20-mile bay placement standard, with the largest recovery occurring at Pair 88.

Survey findings. Of 102 survey responses collected across three RCUT corridors, 11 of 12 business respondents who answered the revenue question reported flat or increased revenue after installation, and only one reported a decline. A perception gap was observed between businesses, which reported that congestion worsened, and residents, who reported that safety improved, consistent with prior literature.

Recommendations. This study developed a categorized RCUT screening tool evaluating site characteristics across three suitability tiers, a set of enhancement methods triggered by specific site conditions (signalization, U-turn crossover placement, compensatory access, wayfinding, and pedestrian infrastructure), and a structured community outreach protocol spanning pre-construction, construction-period, and post-installation engagement. A future-research agenda identifies priority extensions including statewide RCUT database development, longer post-installation observation windows, and integration of third-party transaction data.

CHAPTER 1. INTRODUCTION

This chapter introduces the project background, the research problem, the research objectives, and the organization of the report.

1.1 PROJECT BACKGROUND

The Georgia Department of Transportation (GDOT) has implemented Restricted Crossing U-Turn (RCUT) intersections at multiple locations across the state as part of ongoing efforts to improve operational efficiency and safety along high-volume corridors. An RCUT reduces the number of conflict points at a four-leg intersection by prohibiting through and left-turn movements from the minor approaches and redirecting these movements to downstream median opening on the major road. Documented benefits include reductions in serious-injury crashes and improved major-road throughput.

Despite these operational and safety benefits, RCUT installations frequently generate concern among adjacent business owners during the planning phase, who anticipate revenue loss associated with the reconfigured access pattern. Research Project RP 24-12, Economic Analysis of RCUT Access Impacts in Georgia, was awarded to the Georgia Institute of Technology by GDOT to develop quantitative evidence of post-installation economic outcomes and to translate that evidence into siting and design guidance suitable for application across GDOT districts. The research aligns with GDOT's broader goals of improving transportation infrastructure while minimizing adverse effects on adjacent communities.

1.2 RESEARCH PROBLEMS

Three considerations motivate this study.

First, GDOT planners and district staff currently lack Georgia-specific quantitative evidence to engage adjacent business communities during the RCUT planning process. Prior research conducted for the North Carolina Department of Transportation (NCDOT) and the Louisiana Department of Transportation and Development (LADOTD) has examined the safety, operational, and economic impacts of RCUT and median-restrictive treatments. However, neither body of work is directly transferable to Georgia. The NCDOT work focuses primarily on safety and operational outcomes with limited economic analysis, and the LADOTD economic study uses business-level sales tax records that are not available to Georgia researchers.

Second, Georgia confidentiality law (O.C.G.A. § 48-2-15) precludes researcher access to business-level sales tax data, foreclosing the most direct economic outcome variable used in prior state studies. A defensible Georgia analysis must therefore rely on a multi-proxy framework drawing on data sources that remain accessible: parcel-level property valuations, satellite-derived nighttime radiance, collision records, and stakeholder surveys. No standardized framework for this proxy-based approach currently exists in the RCUT economic literature.

Third, Georgia's corridor commercial typology differs from the Mid-Atlantic and Gulf Coast contexts that dominate the existing RCUT literature. Rural and suburban Georgia corridors are characterized by a mix of plaza-anchored chain commerce, isolated impulse-purchase businesses (gas stations, convenience stores, quick-service restaurants), and light-industrial parcels. Economic outcomes observed in other states cannot be assumed to generalize without site-specific Georgia evidence.

Together, these considerations establish the need for a Georgia-specific, proxy-based methodology for evaluating RCUT economic impacts, supported by empirical evidence drawn from operational Georgia installations.

1.3 RESEARCH OBJECTIVES

The objective of this research is to identify changes to patterns in access after installation of an RCUT intersection and any associated changes to economic performance of the impacted businesses nearby. Specifically, the objectives are to:

1. Describe overall business accessibility relative to an RCUT intersection
2. Collect and analyze available economic data for the businesses surrounding Georgia's RCUT installations.
3. Provide information on overall economic trends for these businesses as well as analyses for common business types.
4. Provide an overall summary of the expected changes to access patterns and economic activity upon RCUT installation in any given area.

To accomplish these objectives, this study carried out five work tasks consistent with the approved Statement of Work for GDOT Research Project RP 24-12. Each task is described below.

Task 1: Conduct a comprehensive literature review on existing RCUT literature. This study conducted a comprehensive literature review on the existing design of RCUT intersections and the methods used in prior studies and surveys. Special attention was paid to four key areas: local

access patterns, travel times, economic impacts, and safety. The review analyzed relevant academic papers and publications from states where RCUTs are in use. It provided a solid foundation for the subsequent phases of the research, informing the selection of appropriate methodologies and enabling a deeper understanding of the potential impacts of RCUT intersections on local businesses.

Task 2: Perform site selection and data acquisition. Building on the understanding of RCUT research, implementation, and public opinion obtained in Task 1, this study selected RCUT projects for analysis in consultation with GDOT engineers. Site categories included rural versus urban, high versus low traffic volume, different speeds, and different types of local business presence. During this step, the study determined the availability of economic data at each selected location and collected it to the extent possible.

Task 3: Conduct industry survey and interviews. The main concerns of local businesses in Georgia were collected through a survey of businesses in areas where RCUTs have been constructed. The survey provided insight into attitudes surrounding RCUTs and their impact on project development, which served as a reference point for the study's conclusions and recommendations. In addition to the survey, this study conducted interviews with selected local businesses willing to share their opinions, including whether the safety improvement benefitted their customers and their business.

Task 4: Perform data analysis and impact evaluation. In this task, the collected data were converted into meaningful information. For each affected business, the study identified relevant factors and their relationship to RCUT geometry, including business type, business age, number of access points, connections, and placement relative to U-turn lanes; additional factors were

identified during the research. Elements of RCUT design, such as the configuration of additional access points and U-turn locations, were also noted. These elements were correlated with the economic performance of businesses in each category to clarify how roadway and business characteristics interact. As many confounding factors as possible were controlled for, with the method varying by available data but generally including adjustments for inflation and regional economic growth. The analysis produced Georgia-specific statistics on RCUT effects that did not previously exist. Based on the observed impacts, the study drew conclusions and developed recommendations for refined RCUT design to mitigate business concerns, reporting the correlations between economic performance and the identified factors and exploring design measures to support local businesses.

Task 5: Develop outreach methods and complete the final report. In this task, a draft final report summarizing the outcomes of Tasks 1 through 4 was developed. Preliminary informational materials and outreach methods were prepared to help future RCUT projects address the concerns of local businesses and to explain the positive effects that such intersection designs can have on local traffic and economic performance. This study also recommends incorporating the research outcomes, such as the potential impact on local businesses, into the cost-benefit analysis used to select countermeasures at RCUT intersections.

1.4 REPORT ORGANIZATION

The remainder of the report is organized as follows. Chapter 2 presents the literature review of RCUT performance, prior state DOT studies on economic impacts, and the gaps that motivate this study. Chapter 3 documents the methodology for the economic impact analysis, including site selection, data collection, the property valuation difference-in-differences (DiD) analysis, the

VIIRS Modified Interrupted Time Series (MITS) analysis, and the cross-method triangulation procedure. Chapter 4 presents the accessibility analysis framework, including the spatial framework, data inputs, and the exponential distance-decay model. Chapter 5 documents the qualitative survey methodology, including survey design, sample and data processing, and the statistical methods used to analyze the responses. Chapter 6 presents the empirical results from the four analytical components, applied to the four primary treatment–control pairs with supporting evidence from secondary pairs. Chapter 7 presents the implementation framework, including the RCUT screening tool, the RCUT enhancement criteria, community and business outreach, and the GDOT implementation roadmap. Chapter 8 summarizes the research contributions, key findings, limitations, and recommendations for future research. Appendix A provides the site inventory, Appendix B the survey instrument and full results, Appendix C the guideline visuals, and Appendix D the crash and safety analysis.

CHAPTER 2. LITERATURE REVIEW

This chapter synthesizes existing knowledge on RCUT performance, and the methods used by prior state Department of Transportation (DOT) studies to evaluate economic impacts. The chapter begins by stating the objectives of the literature review. It then reviews the documented Benefits of Restricted Crossing U-Turns, including traffic flow and efficiency, safety improvements, cost-effectiveness, and perceptions of local businesses. State Department of Transportation Approaches to Economic Impact follows, summarizing analytical methods and reported findings from prior state studies, along with the economic proxies used when sales data are unavailable. The chapter concludes with Gaps in the Existing Research that motivate the present study.

2.1 OBJECTIVES OF THE LITERATURE REVIEW

Document the established safety and operational benefits of RCUT intersections relative to conventional intersection designs, providing context for why economic impact evaluation is warranted.

Synthesize existing evidence on the economic impacts of RCUTs and analogous access management treatments on adjacent businesses, property values, and corridor-level economic activity.

Identify and evaluate the methodological approaches used in prior DOT-sponsored economic impact studies, with particular attention to data sources, analytical frameworks, and their respective limitations.

Identify gaps in the existing literature that the present study is designed to address, including limitations related to geographic scope, sample size, macroeconomic controls, and the availability of administrative economic data in Georgia.

2.2 BENEFITS OF RESTRICTED CROSSING U-TURNS (RCUTS)

RCUT intersections, also referred to as J-turns or superstreets in some jurisdictions, are an alternative intersection design developed to address the safety and operational deficiencies of conventional intersections. By prohibiting direct left-turn and through movements from the minor road and rerouting those vehicles through a dedicated downstream U-turn, the design eliminates the highest severity conflict points at the main intersection while preserving the major-road throughput. The following sections summarize the traffic flow, safety, and cost benefits documented in the existing literature, which together establish the operational baseline against which the economic effects evaluated in this study should be interpreted.

Traffic Flow and Efficiency

Improved Throughput: RCUTs can increase intersection throughput by up to 30% and reduce network travel time by up to 40% [1].

Simplified Signal Phases: At signalized intersections, RCUTs can reduce the number of signal phases from four or more to as few as two primary phases, allowing for longer green times and shorter overall cycle lengths [2].

Reduced Delays: By eliminating direct left turns and straight-through movements from minor road approaches, RCUTs minimize congestion on major highways.

Studies found that 78% of minor road left turning and through movements merged into travel lanes within the first 400 feet of the acceleration lane at RCUT sites [3]. Studies have shown that RCUTs have travel time, delay, signal progression, pedestrian crossing, and transit services advantages over traditional intersections [4].

Safety Improvements: Crash and Severity Reduction

Reduction in Conflict Points: The safety improvements of RCUTs come from the elimination of severe conflict points, such as left turns. A conflict point occurs when there is a possibility of collision with two vehicles occupying the same position [3]. The reduction of vehicle-to-vehicle conflict points at a four-approach intersection falls from 32 to as few as 14. This reduction helps lower collision opportunities, as seen in **Table 1**.

Table 1: Severity Reductions RCUT vs Conventional Intersection Comparison

Number of Approaches	Type of Conflict	Conventional Intersection Conflict Points	RCUT Intersection Conflict Points
3	Vehicle-to-Vehicle	9	7
3	Vehicle-to-Pedestrian	12	5
4	Vehicle-to-Vehicle	32	14
4	Vehicle-to-Pedestrian	24	8

Severity Reduction: With the reduction in conflict points and collision opportunities, this supports the reduction in severe crash types. Studies consistently show that RCUT intersections lead to sustainable reduction in severe crashes, including reductions in fatal crashes. Disabling injury crashes per year decreased from 2.3% to 0.3%, and minor injuries from 5.3% to 2.6% [3]. The reduction in fatal crashes is well-documented. In Minnesota, with the installation of RCUTs

a before-after analysis yielded a 69% decrease in fatal and serious injury crashes and a 70% decrease in angle crashes [5]. Some locations post-RCUT installation resulted in the elimination of fatal crashes during the observed window [4, 5].

Cost-Effectiveness and Reduced Maintenance

The Federal Highway Administration (FHWA) states that RCUT intersections are adaptable for different circumstances, including being implemented in rural areas, high-speed locations, urban, and multi-corridors [6]. RCUTs are also less costly alternatives to constructing an interchange, compared to other intersections such as roundabouts. [6] RCUT implementation can extend the useful operational life of the arterial before additional capital improvements become necessary, thereby reducing long-term infrastructure costs [2].

Perceptions of Local Businesses

Local businesses often object to the installation of RCUTs at existing intersections due to concerns about potential loss of business [7]. These objections primarily stem from five categories of concern identified consistently across the literature:

Perceived reduced accessibility: Businesses fear that modifying or limiting direct access to their properties will make it more difficult for customers to reach them, potentially leading to a loss of business [7].

Changes in traffic patterns: A study on raised medians documents that business owners commonly anticipate that altered traffic patterns will reduce passerby access and deter customers, it is documented that businesses present before, during, and after raised median installations reported no net change in passerby traffic overall [8].

Construction-phase impacts: There are documented perception gaps between businesses that anticipated construction and actual impacts. A report in Texas showed an expected 18.6% decline in gross sales, while those actually experienced full before-during-after period reported a realized decline of only 10.7% during constructing and near-complete recovery afterwards, with gross sales essentially unchanged from pre-construction levels [8].

Lack of awareness on RCUT benefits: Many businesses are not fully informed about the potential long-term benefits of RCUTs prior to installation. Schneider et al. (2019) observed that despite ample evidence of safety and mobility improvements, J-turn projects frequently encounter local opposition from businesses predominated concerned with access impacts [7].

Studies show that businesses surveyed before construction were significantly more pessimistic about customer retention than those who had lived through the construction period, suggesting that pre-construction outreach and education about operational benefits may help close this perception gaps on RCUTs [8]. Consistent with this, Frawley and Eisele (2000) found that businesses surveyed before construction were significantly more pessimistic about post-construction customer retention than those who had experienced the full before-during-after period [8]. This is a pattern that suggests pre-construction education about realized outcomes could meaningfully reduce stakeholder opposition and support further RCUT installations.

2.3 STATE DEPARTMENT OF TRANSPORTATION APPROACHES TO ECONOMIC IMPACT

State Departments of Transportation (DOTs) have developed several methodological approaches to evaluate the economic impacts of RCUTs. Broadly, these approaches fall into three categories:

1. Analyses based on data provided from the state department of revenue, such as sales tax data.

2. Property value and satellite-based data as an economic proxy when sales data is unavailable.
3. Survey-based approaches that capture perceptions and experiences of businesses and corridor users.

Texas Department of Transportation Study

The foundational entry in the access management economic impact literature is the Texas study conducted by the Texas Transportation Institute (TTI) at Texas A&M University and published in October 2000 [8]. Sponsored by the Texas Department of Transportation (TxDOT), the project's primary objective was to develop and test a replicable methodology for estimating the economic impacts of raised median installations on adjacent businesses and properties. An important framing distinction must be noted: the treatment examined is a raised median rather than an RCUT, and direct transferability is therefore limited, although both treatments eliminate minor-road left-turn and through movements. The methodology was developed and piloted on Texas Avenue in College Station during the first year of the project and extended to additional corridors during the second year, yielding a final dataset of 11 corridors across 8 cities (including Houston, Port Arthur, McKinney, Longview, Wichita Falls, and Odessa) with 163 business surveys analyzed in the aggregate. A separate component examined 13 sites in Amarillo, Texas, where raised medians had been removed rather than installed, and these are documented as a distinct case. Data collection relied on three instruments: personal interview and mail-out surveys administered to business owners and managers, a customer survey conducted at five business locations along the Texas Avenue corridor in College Station, and an undeveloped land survey for vacant parcels adjacent to select corridors. No control group was used and no causal identification strategy was applied; the analytical approach is a

descriptive before-and-after comparison relying entirely on self-reported data. To enable longitudinal comparison, businesses were classified into four groups based on their operational status relative to median construction. Group 1 comprised businesses present before, during, and after construction and provides the most reliable basis for pre- and post-construction comparison. Group 2 consisted of businesses surveyed prior to construction, whose responses capture anticipated rather than realized impacts. Group 3 and Group 4 covered businesses that arrived during or after construction, respectively [8].

The most consistent finding across the study is a gap between anticipated and realized impacts. Among Group 2 businesses interviewed before construction, 19% expected their regular customers to be less likely to visit after installation; among Group 1 businesses that had lived through the full construction cycle, only 14% reported this outcome. Group 2 businesses anticipated an 18.6% reduction in gross sales during the construction phase, while Group 1 businesses reported an actual reduction of 11.6% during that same phase. The most striking perception gap appeared in property values: Group 1 businesses reported an actual increase of 6.7% after construction, while Group 2 businesses had anticipated a 2.3% decrease, a reversal rather than a moderated version of the feared outcome. The construction phase was consistently identified as the most disruptive period. Group 1 businesses reported a 14.9% decrease in customers per day during construction, which reversed to a 17.7% increase after construction was complete, and gross sales fell 11.6% during construction before recovering to essentially flat (-0.03%) post-construction. Recovery was not uniform across business types. Gas stations and auto repair shops were the most persistently affected: gas stations reported a 17.6% decrease in customers per day and a 2.4% decrease in gross sales that did not recover after construction ended, along with a 17.5% decrease in passerby traffic, the largest among Group 1

businesses. Durable retail, specialty retail, fast-food restaurants, and sit-down restaurants generally reported flat-to-slightly-positive outcomes in gross sales after construction. Customer surveys conducted at five business locations along Texas Avenue indicated that accessibility to store ranked 4th or lower in importance across all business types, consistently below product quality, customer service, and price. The primary reason customers cited for being less likely to visit a business was that access had become more difficult, while the primary reason for being more likely to visit was improved safety. The Amarillo median removal component documented 13 removal sites with 22 personal interviews; businesses present before, during, and after the removal reported a 3.9% per-year increase in gross sales following removal and a 3.7% increase in passerby traffic. The Amarillo median type was substantially different from the raised medians examined at the other 10 corridors, limiting direct comparison within the same study [8].

The primary limitations of the Texas study are the absence of any control group, the lack of a causal identification strategy, and the reliance on self-reported sales and property value data, which is subject to recall bias. The treatment is also a raised median rather than an RCUT, which limits direct comparability of the property value and sales findings. However, both treatments share the elimination of minor-road through and left-turn movements, which makes the perception-related findings broadly transferable. The most useful element for the present study is the four-group business classification framework, which separates anticipated impacts from realized impacts and provides a structural explanation for the perception-outcome gap reported in subsequent state studies. The Texas finding that pre-construction fears consistently exceeded realized post-construction impacts motivates the question-ordering protections built into the survey instrument described in Chapter 5 of this report. The Texas study

also establishes the business-type sensitivity pattern (gas stations and auto repair as the most pass-by-dependent and impulse-sensitive categories) that informs the business vulnerability tier classification used in the Phase 1 screening tool presented in Chapter 7 [8].

Louisiana Department of Transportation and Development Study

One of the most rigorous applications of administrative data in RCUT research is the Louisiana study conducted by the Highway Safety Research Group and Economics and Policy Research Group at Louisiana State University (LSU) [7]. The study was sponsored by the Louisiana Department of Transportation and Development (DOTD) and conducted in cooperation with FHWA. The primary data source was anonymized sales tax records provided by the Louisiana Department of Revenue for individual business locations, with RCUT site location data provided separately by DOTD. The study covered 10 completed RCUT projects across four parishes (East Baton Rouge, Lafayette, St. Tammany, and Jefferson), analyzed within a symmetric window of two years before and two years after project completion. All businesses matched to the Department of Revenue tax database within a 0.5-mile radius of each RCUT were included in the analysis. To produce consistent sales estimates, raw tax collections were divided by the applicable statewide sales tax rate for each period, a step necessitated by Louisiana's statewide rate increase from 4% to 5% in 2016. The resulting sales figures were then expressed as a share of parish-wide sales to control for broader regional economic conditions, including the August 2016 flooding in Baton Rouge and the oil and gas sector slowdown that depressed Lafayette's economy in 2015 and 2016. Within each level of analysis, businesses were classified as "affected" or "unaffected" based on whether RCUT installation increased customer travel distance to the location; unaffected businesses explicitly served as a local control group to isolate any RCUT effect from broader corridor-level trends. A secondary analysis was restricted to

businesses continuously active from at least 12 months before through 12 months after installation, separating incumbent business performance from turnover-driven changes in the sales data. Gas stations and restaurants were additionally examined as a distinct subgroup given their heightened dependence on ease of access and pass-by traffic. The study also administered in-person business and patron intercept surveys at all four parish locations using Qualtrics; questionnaires were explicitly designed to avoid priming respondents to think about the RCUT specifically [7].

At the aggregate level, the mean share of parish-wide sales attributable to businesses near RCUTs increased from 0.22% before installation to 0.28% after, a statistically significant change ($p < 0.05$). Mean nominal monthly sales in the corridors increased from approximately \$9.6 million to \$13.1 million, also statistically significant ($p < 0.05$). These increases were observed in both affected and unaffected business groups, which the authors interpret as evidence that factors beyond the RCUT, such as new commercial development and population growth in the surrounding corridors, contributed to aggregate sales growth. At the parish level, results were broadly consistent, with mean sales stable or increasing in East Baton Rouge, Lafayette, and Jefferson parishes. The one notable exception was St. Tammany Parish, which showed a significant increase in total corridor sales as a share of parish sales overall, but a decline in sales among incumbent businesses active throughout the study period. The authors attribute this pattern to intensified local competition from new commercial development nearby, including a newly opened Walmart, rather than to the RCUT itself; the decline was observed in both access-affected and access-unaffected incumbent businesses alike, making an RCUT-specific access explanation implausible. Across survey locations, open-ended responses from both business managers and patrons consistently identified congestion, traffic backups, and

ongoing construction impacts as the primary access-related concerns rather than the RCUT geometry itself. In the Broussard corridor specifically, where construction had been ongoing for several years, 70% of patron comments referenced construction directly. Access ranked 4th or 5th in importance among the six patron and business considerations evaluated, consistently below quality, customer service, price, and distance. Overall, the study found no evidence at any level of analysis (aggregate, installation-year cohort, parish, or business type) that RCUT installations negatively affected business sales; sales were positively correlated with corridor growth, although the authors note that this correlation cannot be causally attributed to the RCUT intersection alone [7].

The Louisiana study's primary limitation is that parish-level sales trends serve as the only external macroeconomic control, which cannot fully account for highly localized factors affecting individual corridors. The aggregate framing can also mask individual business-level losses where corridor totals continue to grow due to new development. As the only published state DOT study to use direct administrative sales tax records at the individual business level to evaluate RCUT economic impacts, this report represents the closest available analog to ground-truth economic data within the RCUT literature, and its affected-versus-unaffected classification and parish-share normalization framework provide a strong methodological template wherever sales tax revenue data are obtainable. Direct application of this approach in Georgia is not possible because the Georgia Department of Revenue does not release business-location-level sales tax records to outside researchers, a constraint documented in Chapter 3 of this report and one of the primary reasons the present study relies on parcel-level assessed property values and VIIRS nighttime radiance as administrative-data proxies. The Louisiana survey protocol,

particularly the explicit design choice to avoid RCUT-specific priming in questionnaire wording, also informs the survey instrument used in this study, as described in Chapter 5 [7].

North Carolina Department of Transportation Study

The most methodologically diverse entry in the RCUT economic literature is the North Carolina study, published in 2022 and conducted by a multidisciplinary team at the University of North Carolina Wilmington [14]. Sponsored by the North Carolina Department of Transportation (NCDOT) and conducted in cooperation with FHWA, the study examined economic impacts through four complementary methods: a nighttime light (NTL) remote sensing analysis using VIIRS satellite data, a business perception survey, a residential real estate analysis, and a residential survey incorporating a discrete choice experiment (DCE). This multi-method design reflects the authors' explicit recognition that the economic impacts of RCUT installations could fall on the supply side through effects on businesses, on the demand side through effects on consumer behavior, or elsewhere entirely, such as in residential property values as households price in the time and safety implications of living near an RCUT corridor. The remote sensing component used monthly VIIRS Day/Night Band radiance composites accessed through Google Earth Engine as a proxy for economic activity, applying a multi-group interrupted time series approach that compared treated developments to matched control developments over a two-year pre and two-year post installation window, with the construction period excluded from analysis. Sites were required to have been installed after 2014, to have a population density of at least 500 persons per square mile, and to have a suitably sized commercial or industrial development with an appropriate control development within proximity. Three areas were selected for the remote sensing analysis: the NC 55 Bypass and Avent Ferry Road corridor in Holly Springs, a corridor of RCUT improvements along US 74 in Union County southeast of Charlotte (Indian

Trail), and the NC 49 and Stough Road intersection in Concord. The residential real estate component applied a formal difference-in-differences (DiD) design to four RCUT installations along South College Road in Wilmington, North Carolina, using home sale price data from the New Hanover Tax Assessor's Office. Treatment streets were those that lost the ability to turn left onto the arterial following RCUT installation, while nearby streets that had never had a median opening served as controls [14].

Results from the remote sensing analysis were mixed and depended heavily on development type. For commercial developments, most model comparisons returned a null effect, with one notable exception: the Holly Springs center, which showed a significantly positive effect of approximately 20%. The authors attribute this exception to the specific geometry of that intersection, which allows customers to reach the development without requiring U-turns from any direction. For industrial developments, the results were more consistently negative; two of the three industrial parks near the Indian Trail corridor showed decreased economic activity following RCUT installation, with the decline reaching statistical significance for one park and approaching significance at the 88% confidence level for the other. The authors attribute the divergence between commercial and industrial outcomes to the higher time and maneuverability costs that U-turns impose on industrial vehicles, which are borne by the businesses themselves rather than diffused across a large customer base. Residential real estate results were mixed across the four South College Road sites. Greenbriar Road, which had an unsignalized U-turn, showed a positive and statistically significant effect. Mohican Trail and Hidden Valley Road, also with unsignalized U-turns, produced positive but statistically insignificant results. Wedgefield Drive, the only site with a signalized U-turn, showed a negative and statistically significant effect. The authors interpret this pattern as evidence that the traffic flow

benefits of RCUT installation support or maintain home values, but that the additional waiting time imposed by a signalized U-turn can offset those benefits for nearby residents. The business survey found that businesses with larger customer volumes and those serving customers during peak congestion periods were more likely to report that RCUTs make their businesses easier to reach, while industrial businesses were significantly less likely to agree and more likely to express safety concerns related to truck traffic navigating U-turns. The residential DCE, administered to both an online panel and a mail sample, asked respondents to trade off accident reductions against additional time to turn left and additional total commute time. Across both samples, respondents demonstrated strong preferences for safety and were willing to accept roughly one to two minutes of additional U-turn time for a 10% reduction in accidents. Respondents were consistently more averse to additional left-turn time than to equivalent increases in total commute time, which the authors interpret as evidence that drivers particularly dislike waiting in a fixed position, such as at a signalized U-turn [14].

The North Carolina study's primary limitations are that most VIIRS multi-group ITS models returned null effects, the remote sensing analysis captures only corridor-scale rather than parcel-level activity, and the residential DiD applies to only four treatment sites along a single arterial. The authors also acknowledge that stated preferences from the DCE may diverge from revealed behavior, and that the radiance-based economic activity measure is limited by VIIRS pixel resolution to larger commercial and industrial developments, precluding analysis of smaller individual businesses. Despite these limitations, the North Carolina study is the most directly applicable methodological reference for the present work. Three elements are adopted and extended in this study: the VIIRS-based multi-group ITS approach is extended to a Modified Interrupted Time Series (MITS) specification applied across the four primary Georgia treatment-

control pairs described in Chapter 3; the parcel-level real estate DiD is extended from four sites on a single arterial to four primary Georgia pairs with full parcel coverage within a 0.5-mile buffer; and the unsignalized-versus-signalized U-turn distinction that drove the divergent property value results at Wilmington informs the geometric inputs to the accessibility decay model presented in Chapter 4. The multi-method design itself is the most important conceptual contribution: no single proxy measure is sufficient for RCUT economic impact evaluation, and convergent evidence across methods strengthens causal interpretation. The present study extends this approach by adding a fourth analytical layer, a geometry-based accessibility decay model, that links the physical RCUT design to predicted economic outcomes [14].

Synthesis of State DOT Approaches

Across the three state DOT studies reviewed, two consistent patterns emerge. First, the perception-outcome gap documented in Texas - pre-construction businesses anticipating sharper declines than post-construction businesses ultimately report - is reproduced in both the Louisiana and North Carolina studies, indicating that the gap is a stable feature of access management deployment rather than a Texas-specific artifact. Second, business-type heterogeneity is observed across all three studies: pass-by and impulse-dependent businesses (gas stations, restaurants, specialty retail) and industrial users consistently show the largest divergence in measured outcomes from corridor averages. The three studies differ primarily in the data sources used to measure economic impact, with Texas relying on self-reported surveys, Louisiana on administrative sales tax records, and North Carolina on a multi-method combination of VIIRS remote sensing, residential real estate DiD, business surveys, and a discrete choice experiment. **Table 2** summarizes the methodological characteristics, key findings, and limitations of each study

Table 2: Summarizes the methodology of three key DOT-sponsored economic impact studies reviewed.

Dimension	Texas [8] 2000	Louisiana [7] 2019	North Carolina [14] 2022
Treatment type	Raised medians. Both treatments remove left-turn movements.	RCUTs (J-turns)	RCUTs (superstreets / RCIs)
Number of sites	11 corridors across 8 Texas cities; 163 business surveys	10 J-turn projects across 4 parishes	Multiple sites: 4 intersections for real estate DiD; 3 areas for remote sensing
Study window	Variable, 3-18 years post-construction	2 years pre / 2 years post	2 years pre / 2 years post (remote sensing); variable for real estate DiD
DATA AND METHODS			
Primary data source	Business owner and customer surveys, self-reported gross sales, property values, and employment	Administrative sales tax records (Louisiana Dept. of Revenue); J-turn locations from DOTD	Multi-method: VIIRS NTL remote sensing via GEE, business surveys, home sale prices (New Hanover Tax Assessors Office), DCE
Control group	None: simple before-after design	Unaffected businesses (no change in customer travel distance), parish-level sales as external benchmark	Matched control developments (remote sensing); proximate unimproved streets (real estate DiD)
Causal identification	None: purely descriptive	Before-after normalized to parish-level sales trends; affected vs. unaffected business.	DiD for real estate; MITS, for remote sensing; descriptive for business survey
Macroeconomic controls	None	Parish-level sales trend as denominator; statewide tax rate change, corrected via rate deflation	Matched control sites absorb regional trends.
KEY FINDINGS			
Overall economic impact	Generally null to positive post construction. Aggregate sales essentially flat. After construction, customers per day up increased. Construction phase was most disruptive period.	Aggregate sales increased significantly. No significant negative findings attributable to RCUT installation at any analytical level.	Null to slightly positive for commercial development. Negative for industrial development. Mixed for residential real estate.
Business type differentiation	Yes: gas stations and auto repair most sensitive. Specialty retail, restaurants largely unaffected or slightly positive.	Yes: gas stations and restaurants analyzed as a formal subgroup given heightened pass-by and impulse access dependence	Yes: retail/service developments neutral to positive; industrial users significantly less likely to view RCUTs favorably and negatively affected in radiance data
Perception gap	Yes: pre-construction group anticipated decrease gross sales and property values. Post-construction group reported decrease in construction then flat and increase after. Anticipated impacts consistently exceeded realized impacts.	Partial: business resistance is documented, but surveys were post-construction only (no pre-construction perception baseline). Respondents attributed access concerns to congestion and construction, not RCUT.	Yes: pre-construction pessimism not borne out for commercial development. Industrial concerns were more warranted by the data.
Property value finding	+6.7% actual increase (post-construction group) vs. -2.3% anticipated decrease (pre-construction group).	Not analyzed	Mixed DiD results across 4 intersections.
LIMITATIONS			
Economic analysis	No control group, no causal identification, no macroeconomic controls. Heterogeneous corridors averaged together. Perception-based only, not drawn from administrative records	Parish-level trends are the only external control, cannot account for highly localized corridor factors. Aggregate framing can mask individual business-level losses where corridor totals grow.	Most VIIRS multi-group ITS models returned a null effect; remote sensing only captures corridor analysis.

While these three studies represent different analytical approaches to RCUT economic impact evaluation, the underlying data sources and proxy measures warrant more detailed treatment given their central role in the present study. The following section reviews remote sensing, property values, and survey instruments in turn, with attention to the strengths and limitations of each.

Economic Proxies

Remote sensing and Nighttime light data as proxies for Economic Activity

A key methodological innovation in the NCDOT study is the remote sensing approach; it is important to briefly review how nighttime light data function and their relevance to economic measurement. Remote sensing has emerged as an important tool for analyzing and observing human economic activity when traditional data sources are unavailable or lack sufficient spatial resolution for localized studies [9]. One of the widely used indicators is nighttime lights (NTL) data, which captures artificial illuminations from urban areas, infrastructure, and commercial activity [10]. Since artificial lighting is closely associated with human activity; NTL intensity has been widely used as a proxy for economic development and spatial patterns of activity [11]. A substantial body of research supports the use of nighttime light data as a proxy for economic activity. Early work by Chen and Nordhaus (2011) demonstrated strong relationships between luminosity and macroeconomic indicators such as GDP, particularly in data-scarce regions.[12] The most used dataset in recent application is derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band, which can detect low levels of nighttime illumination [11]. The VIIRS night-time lights involve a series of filtering steps to remove cloud coverage, solar and lunar illuminations, stray lights, lightning, high energy particles (HEP), and other features unrelated to electric lighting, prior to temporal averaging. Compared to other

datasets, this results in producing high quality global radiance composites of human settlements [10]. However, these relationships may weaken in low-density or rural areas with limited artificial lighting, a limitation that is particularly relevant for the rural and exurban of RCUT sites [13].

Property Value as proxies for Economic Activity

Property values adjacent to RCUT and other access management treatments represent a secondary but important economic outcome in the literature. The relationship between access management and property values operates through two primary mechanisms. First, improvements in traffic safety and reductions in crash risk increase the desirability of corridor-adjacent properties. Second, improved arterial throughput and travel time reliability enhance accessibility, expanding the effective market area and supporting higher land values.

In the RCUT-specific context, Barnes et al. (2022) found mixed results from a residential real estate difference-in-differences analysis. One RCUT site showed a statistically significant increase in nearby home prices, two showed positive but insignificant effects, and one site with a signalized U-turn showed a negative effect [14]. All three intersections with a positive effect, were unsignalized U-turns as a part of the RCUT design. The one that had a negative effect on property values had a signalized U-turn. The authors attributed the negative results due to the imposed signal control offsetting the safety benefits of the RCUT. Overall, the literature suggests that property value impacts are context-dependent and influenced not only by access management itself but also by specific design features and local conditions. While safety and accessibility improvements may increase property desirability, perceived access constraints or

operational delays can offset these benefits in certain cases. These findings support the inclusion of property value analysis as a complementary measure of economic impact.

Survey based methods

Survey-based methods play an important complementary role in evaluating the economic impacts of RCUT and access management treatments. While administrative data and proxy measures provide objective indicators of economic performance, surveys capture perceptions, behavioral responses, and decision-making processes that are not directly observable in quantitative datasets. Previous studies have used surveys to assess how businesses and corridor users perceive accessibility changes.

Both TxDOT and NCDOT found that business owners often anticipate more severe negative impacts than are ultimately realized [8, 14]. In Louisiana, integrated surveys with administrative sales tax data, finding that concerns about access were not borne out in observed sales figures and that perceptions of ongoing construction impacts were a primary driver of business anxiety [7]. This perception gap highlights the importance of distinguishing between perceived and actual economic effects.

2.4 GAPS IN THE EXISTING RESEARCH

The literature review identified several gaps in the existing research on the economic impacts of RCUTs. Addressing these gaps will provide a more comprehensive understanding of RCUT effects and improve their implementation strategies. The key gaps are as follows:

Broader economic factors insufficiently controlled

While existing studies attempt to account for external economic conditions, their approaches remain limited. The Louisiana study incorporates regional comparison areas and administrative sales tax data to control for broader trends, representing a more rigorous approach than earlier work. However, it does not include systematic macroeconomic covariates, such as unemployment, income, or inflation, within a formal econometric framework. The Texas study relies primarily on survey-based methods and simple before-and-after comparisons, with even more limited control for external factors. These limitations become particularly important in more recent contexts, where RCUT installations may coincide with broader economic disruptions, including the COVID-19 pandemic, requiring more comprehensive control strategies.

Competitive dynamics and spatial redistribution

Although studies acknowledged that RCUTs might create competition by making some businesses more accessible than others, none fully explored how this competitive dynamic affects existing businesses or whether RCUT installation redistributes economic activity along the corridor rather than destroying it.

Generalizability to other states and contexts

Much of the research has focused on specific states, Louisiana, North Carolina, and Texas, and may not be directly applicable to other regions with different economic, geographic, or cultural conditions. Georgia's rural and exurban RCUT inventory, spanning a wide range of build years and corridor types, provides an opportunity to evaluate RCUT economic impacts in a new and important context.

Customer behavior and shopping patterns over time

While patron surveys were conducted in several studies, there is a need for more in-depth longitudinal analysis of how RCUTs influence customer behavior and shopping patterns over extended post-construction periods. The two-year post-construction window common to prior studies may be too short to capture the full adjustment of consumer behavior and commercial development patterns.

Limited sample size in prior studies

Existing studies typically analyze a small number of RCUT sites, often fewer than ten, and rely on limited survey samples, reflecting broader data availability constraints in this research area.

Complex transportation-land use relationships

The relationship between transportation infrastructure and land use is complex and difficult to isolate. Access changes can influence activity patterns differently in the short term versus the long term. Economic impacts depend not only on changes in access to adjacent properties but also on business activity types and background economic conditions

Remote sensing spatial resolution limitations

Although satellite-based nighttime radiance data provide a useful proxy for economic activity, VIIRS pixel size (approximately up to 742 meters) [10] is too coarse to attribute radiance changes to individual businesses or parcels, limiting its utility for intersection-level analysis. As documented by Barnes et al. (2022), this necessitates buffered measurements that introduce a trade-off between spatial precision and coverage certainty [14]. Additionally, nighttime radiance performs less reliably in the rural and low-density environments [13] characteristic of many

Georgia RCUT corridors, reinforcing the need for the multi-layered data strategy employed in this study.

Survey Bias

Existing studies rely heavily on surveys of businesses and individuals located near RCUT sites, which may introduce several forms of bias. Survivorship bias is a key concern, as businesses that closed following RCUT implementation are excluded from survey samples, potentially understating negative impacts. In addition, priming and attribution biases may affect how respondents interpret changes in access or economic performance, leading to an over- or under-assignment of effects to the RCUT itself rather than to broader economic conditions. Another important limitation is that many surveys are conducted after RCUT implementation, meaning respondents have directly experienced the associated changes in traffic patterns, access, and construction impacts. These experiences may shape responses in ways that reflect short-term disruptions or adjustment periods rather than long-term conditions. Even when survey instruments do not explicitly reference RCUT terminology, recent exposure to these changes can influence perceptions, introducing potential recency or experience-based bias.

CHAPTER 3. ECONOMIC ANALYSIS OF RCUT IN GEORGIA

This chapter presents the methodology for the economic impact analysis. The chapter begins with the objective of the chapter, followed by RCUT and Control Site Selection, which describes the candidate inventory and the four primary pairs adopted for in-depth analysis. Data Collection follows, documenting the absence of business-level sales tax data in Georgia and the property valuation and remote-sensing data sources used in their place. The Economic Impact Analysis section presents the Property Valuation difference-in-differences (DiD) methodology and the VIIRS Modified Interrupted Time Series (MITS) methodology, explains the differences between the two approaches, and describes the cross-method triangulation procedure used to interpret convergent and divergent evidence.

3.1 OBJECTIVE OF THIS CHAPTER

The objectives of this chapter are as follows:

1. Develop a comprehensive framework for RCUT site selection, control-site matching, and data integration for future access management projects. This framework documents the criteria used to select the eight Georgia RCUT sites, four primary pairs (RCUT 63, 79, 88, and 90) and four secondary pairs (14, 53, 71, and 93). The procedures for identifying matched control intersections, and the decision rules governing which analytical methods are applied under varying data availability conditions
2. Analyze the economic and safety effect of RCUT installations on adjacent businesses and communities using a quasi-experimental matched-control design. For each RCUT intersection in Georgia, a nearby non-RCUT intersection with comparable AADT, business

mix, and land use serves as the control, enabling a before-and-after comparison that isolates the RCUT's contribution from statewide economic trends, seasonal cycles, and county-level growth

3. Analyze results across four independent data streams A) Collision records (GDOT), B), Parcel-level property valuations (qPublic/County tax assessors) C), Satellite nighttime radiance (VIIRS), D) Stakeholder perception surveys (business and resident respondents), so that conclusions do not rest on any single measurement instrument. Where direct economic data such as sales or tax receipts were not available, these proxy indicators are combined using difference-in-differences and modified interrupted time series models.
4. Synthesize findings across sites and methods into actionable guidance for GDOT practitioners, including threshold criteria for when RCUT installation is likely to produce neutral or positive economic outcomes, design features associated with adverse property value effects, and recommended pre-construction engagement protocols for corridors where business sensitivity is elevated.

3.2 RCUT AND CONTROL SITE SELECTION

Site selection proceeded in two stages.

1. An inventory of candidate RCUT intersections was created for Georgia and characterized each one by corridor context, surrounding land use, and installation date.
2. Each candidate RCUT was paired with a matched control intersection, a non-RCUT signalized intersection selected, so that any observed post-installation differences between the two sites could credibly be attributed to the RCUT rather than to unrelated differences in

traffic volume, commercial density, or regional economic trends. The matching process relied on a combination of Georgia Department of Transportation (GDOT) records, aerial and historical imagery from Google Earth Pro, and GDOT Average Annual Daily Traffic (AADT) data.

This two-stage approach ensured that treatment and control groups were comparable on the characteristics most likely to confound and begin the economic analysis.

Candidate Inventory and Screening

The initial candidate pool was assembled from GDOT records and subsequently verified through dated aerial and historical satellite imagery in Google Earth Pro. Each candidate was evaluated against a set of structured exclusion criteria designed to ensure data sufficiency, site interpretability, and analytical validity. After applying all criteria, eight RCUT intersections out of approximately 49 RCUT installations statewide were retained for analysis.

Observation Window and Installation Date

The study design requires a minimum of one year of pre installation and one year of post installation data for each analytical method employed. While a two-year pre and post window was the original target, data constraints related to the temporal depth of available county property assessment records required a minimum one-year window for several sites. RCUTs installed after 2024 were excluded from consideration, as the study was conducted during 2025 and 2026 and an insufficient post installation observation period would have been available for meaningful analysis. A substantial portion of Georgia's RCUT inventory predates 2010; sites in this category were retained where data availability permitted and were organized into installation year cohorts to account for variation in the length of the post installation observation window across sites.

Build Year Verifiability

Installation dates were verified by cross referencing GDOT project records with temporally dated Google Earth Pro imagery. Sites for which the installation date could not be independently confirmed whether due to gaps in satellite imagery acquisition schedules or ambiguous construction phasing visible in available imagery, were flagged and excluded from the primary analysis. This criterion was applied to preserve the integrity of the before and after comparison, which is sensitive to uncertainty in the treatment date.

Proximity to Commercial Activity

Sites located in rural Georgia with no adjacent commercial land uses were flagged and removed from the candidate pool, as the absence of nearby businesses renders intersection level economic impact inconclusiveness. Sites whose immediately adjacent parcels consisted predominantly of government buildings or institutional uses were similarly excluded, as such land uses are unlikely to exhibit the revenue sensitive or traffic sensitive economic responses the study is designed to detect.

Control Site Availability

A small number of candidates RCUT sites could not be paired with a suitable control intersection satisfying all matching criteria within the required geographic bounds. These sites were excluded from the final sample to preserve the integrity of the matched design.

Volume Verification

Traffic volume at each candidate site was assessed using GDOT Average Annual Daily Traffic (AADT) data. Because RCUT intersections are typically located along arterial corridors, AADT

figures were not always available at the precise intersection node. In many cases, the most proximate available count represented arterial-level volume rather than intersection-specific demand. Where intersection-level counts were absent, the nearest arterial AADT segment was recorded as an approximating indicator of corridor traffic volume and noted accordingly in the site inventory. Volume data served two functions in the site selection process. First, it provided a general characterization of each candidate site's traffic environment, supporting the classification of sites into volume tiers using 5,000 AADT as the boundary between lower-volume and moderate-to-higher-volume corridors. This threshold is consistent with guidance from the Federal Highway Administration, which identifies a minor street ADT of 5,000 as the operational threshold above which unsignalized RCUT intersections generally require signalization for adequate operations [15]. Second, volume data informed the control site matching process by ensuring that paired treatment and control intersections operated within comparable traffic demand conditions. Sites for which no AADT estimate could be obtained were retained in the candidate pool but flagged, and control site matching for those locations proceeded on land use and corridor type characteristics alone. Pre-period AADT comparability was assessed as the absolute percentage difference between treatment and control. No single tolerance is standardized; we apply a working tolerance of ± 15 -20% as a screening flag, with pairs outside the band retained but disclosed.

Table 3: Site Selection Criteria

Screening Criterion	Disposition
Installation date confirmed as post-2024	Exclude - insufficient post-period observation window
Installation date confirmed as pre-2010	Exclude - predates available parcel and VIIRS data
Installation date between 2010 and 2014	Flag - retain with limited pre-period parcel data noted ¹
Installation date between 2015 and 2024	Include
Build year cannot be verified via GDOT records or Google Earth Pro imagery	Exclude - cohort assignment infeasible
Build year partially ambiguous but assignable to a cohort range	Flag - note in site record
U-turn signal configuration (signalized vs. unsignalized) cannot be verified	Flag - note in site record
No commercial uses identified adjacent to the RCUT intersection	Flag - supplement with Google and OSM imagery for qualitative classification
Adjacent parcels consist predominantly of government or institutional uses	Flag - include only if commercial use is present on at least one quadrant
Site has mixed land use (commercial and institutional present)	Flag - note in site record
AADT available at arterial level only, not at intersection	Include - record as arterial-level estimate; use for approximate tier assignment
No AADT available for candidate site	Include - note; match control site on nearest available volume indicator
No suitable control intersection within 3 miles	Exclude - paired DiD design infeasible

¹ Limited pre-period parcel data: qPublic parcel valuation records generally begin in 2020-2021, so RCUTs built before this window have constrained pre-period property-value coverage available publicly. The local county can provide additional data, however, 0.5miles usually covers many parcels and some counties pull manually.

3.3 DATA COLLECTION

Absence of Business-Level Sales Tax Data

The Louisiana economic analysis study established sales tax records from the state Department of Revenue as the most direct and objective measure of business economic performance in RCUT research. That study benefited from Louisiana's administrative framework, which permitted the release of anonymized, business-level sales tax data to researchers for corridor-specific analysis. A comparable approach was pursued for the present study; however, Georgia law precludes an equivalent data access arrangement.

Under O.C.G.A. § 48-2-15, all tax information collected by the Georgia Department of Revenue (GDOR) is strictly confidential and cannot be disclosed in any form that would reveal the financial records of individual taxpayers or business entities. As a result, GDOR does not release sales tax data at the business, parcel, intersection, corridor, or zip code level. County level aggregate sales tax receipts are available and were obtained for this study. As seen in **Table 4**, this level of geographic aggregation is insufficient for intersection specific analysis.

Table 4: Data Sample of County-Level Gas Station Sales Tax Receipts Obtained from the Georgia Department of Revenue

Row Labels	Sum of Taxable Sales MF	Sum of Taxable Gallons
31-Jan-2021	13,389,378.71	7,512,850.08
1 - Gasoline	9,742,168.25	5,650,909.65
2 - Diesel - Clear	3,621,458.46	1,853,356.43
3 - Aviation Gasoline	25,752.00	8,584.00
5 - Special Fuels	0.00	0.00
31-Aug-2025	7,284,441.60	2,747,219.00
1 - Gasoline	5,970,848.45	2,301,792.00
2 - Diesel - Clear	1,286,227.15	436,305.00
3 - Aviation Gasoline	27,366.00	9,122.00
5 - Special Fuels	0.00	0.00
Grand Total	938,059,834.00	343,544,972.13

A county may contain hundreds of taxable establishments spanning dozens of distinct corridor types, making it impossible to isolate changes in commercial activity attributable to a specific RCUT installation from broader county-wide economic trends. This constraint is not unique to Georgia. Several states maintain similarly restrictive confidentiality provisions that limit researcher access to sub-county tax data, a structural barrier that has contributed to the relatively small number of administratively grounded RCUT economic impact studies nationally. Recognizing this limitation, the present study adopts a multi-proxy data strategy, consistent with

the approach employed by the NCDOT study, integrating parcel-level property valuations, satellite nighttime radiance, collision records, and stakeholder surveys to triangulate economic

Property Value Valuation Data Collection

Parcel level property valuation data were collected using qPublic, a publicly accessible online database maintained by county tax assessors across Georgia. While qPublic provides a convenient starting point for data retrieval, the platform limits historical records to approximately four to five years of assessed values. For any valuation records outside of that available window, direct communication with the local county tax assessor office was required. This process presented a significant practical constraint. In many counties, historical records must be requested and retrieved manually through the assessor office, a process that is both time consuming and resource intensive. Given that the study uses a 0.5-mile buffer around each RCUT and its matched control intersection, a single site can contain thousands of individual parcels. Obtaining complete historical records for all candidate RCUT locations in Georgia through this manual process would not have been feasible within the project timeline or budget. To address this constraint, after going through the RCUT selection criteria, a two-tier sampling approach was adopted.

Four sites were extracted from qPublic for all parcels within a 0.5-mile buffer of both the treatment and control intersections. These sites had sufficient data depth within the qPublic platform to support a two-year pre installation and two-year post installation observation window without requiring manual records requests. For the secondary pairs, the manual records request process was used but limited in scope. Rather than pulling all parcels within the full 0.5-mile buffer, only parcels directly adjacent to the RCUT intersection were identified and submitted to

the local county tax assessor office for retrieval. This reduced the request volume to a manageable number while still capturing the parcels most directly exposed to the RCUT installation. A one-year pre installation and one year post installation window was used for the secondary pairs. Because the adjacent-parcel sample yields only five to seven parcels per side, too few for parcel fixed-effects to converge, the secondary analysis is utilized. Lastly, once received, all property values were organized in Excel and matched to their corresponding RCUT and control pair for analysis.

Remote Sensing Data Collection

Monthly nighttime radiance imagery was obtained from the VIIRS Day/Night Band stray-light-corrected monthly composite (NOAA/VIIRS/DNB/MONTHLY_V1/VCMSLCFG), accessed through Google Earth Engine (GEE).

1. First, latitude and longitude coordinates for each of the eight treatment intersections and their matched control intersections were compiled from the site-selection process. Coordinates were stored in a single master file used as the geographic input to the GEE extraction script. Access the VIIRS VCMSCFG collection in Google Earth Engine. Using a Python script in the GEE Code Editor, the NOAA/VIIRS/DNB/MONTHLY_V1/VCMSLCFG Image Collection was filtered to the study window, yielding one monthly composite image per calendar month.
2. Second, buffer rings were constructed at each site. For every treatment and control intersection, three concentric circular buffers were generated around the site coordinate: 0ft, 330ft, and 1640ft. These three scales match NCDOTs approach specification exactly,

enabling both a within-study test of buffer dilution and a direct comparability check against the North Carolina results.

- An 2640ft buffer was additionally computed as a sensitivity check aligned to the 0.5-mile property value catchment area; it is not part of the primary MITS regression results.
3. Third, the mean radiance per buffer per month is extracted. For each site $\times$ buffer $\times$ month cell, the reduce region operation was applied to compute the area weighted mean of all VIIRS pixels intersecting the buffer polygon. When a buffer straddled multiple VIIRS pixels, the result is a weighted average of those overlapping pixels.
 4. Fourth, the exported CSV is then organized by site, site type (treatment or control), buffer type (0, 330, 1640, 2640), years, months, and columns including mean radiance and pixel count.
 5. Fifth, organized CSV was loaded into the Python analysis script, where it was merged with the site selection inventory and joined with the installation year records that define the pre-, transition-, and post-installation periods for each pair.
 6. Finally, the resulting dataset the monthly observations per site-buffer combination, spanning a multi-year pre- and post-installation window for each of the eight pairs, and is the input to the MITS regression.

3.4 ECONOMIC IMPACT ANALYSIS

Property Valuation Analysis

RCUT installations can alter surrounding commercial activity, particularly for businesses that rely on convenient, impulsive customer access. The Difference-in-Differences (DiD) method isolates the causal effect of the RCUT by comparing how property values changed at parcels near the treatment intersection relative to parcels near the matched control intersection, controlling for regional trends and statewide shocks common to both groups.

Data Preparation

Log Transformation

Parcel assessed values are log-transformed before any analysis:

$$V_{it} \rightarrow \log(V_{it}), V_{it} > 0 \quad \text{Equation 1}$$

The log transformation does two things. It converts the DiD coefficient into an approximate percent change, which is the natural unit for comparing property values across very different corridors. It also compresses the long right tail of high-value parcels, commercial properties and large residential lots, so that a single outlier does not dominate the regression.

Installation Assignment

Each parcel-year observation is tagged as either 1) pre-installation, 2) transition, or 3) post-installation relative to the RCUT build year of its pair. The transition year is dropped before estimation. During the installation calendar year, a parcel is partly exposed and partly not, so

including those observations would attenuate the estimated effect by mixing pre- and post-installation conditions within a single year.

Primary DiD Specification

The core DiD model controls for every time-invariant feature of each parcel and for any statewide annual shock that hits all parcels equally:

$$\log(V_{it}) = \alpha_i + \delta_t + \beta_3(Treatment_i * Post_t) + \varepsilon_{it} \quad \text{Equation 2}$$

In this specification, V_{it} denotes the assessed value of parcel i in year t , expressed in logarithmic form as described above. The term α_i is a parcel fixed effect that absorbs all time-invariant characteristics of each parcel, such as lot size, location, and zoning, while δ_t is a year fixed effect that captures statewide annual shocks common to all parcels, including macroeconomic cycles and reassessment schedules. $Treatment_i$ is an indicator equal to one if the parcel lies within the RCUT corridor and zero if it lies within the matched control corridor, and $Post_t$ is an indicator equal to one for years following RCUT installation and zero for years before. The coefficient of interest, β_3 , is the difference-in-differences (DiD) estimate; it measures how much parcel values in the RCUT corridor changed relative to the control corridor after installation, thereby isolating the effect attributable to the RCUT from broader regional trends. Finally, ε_{it} is the error term, capturing unobserved parcel- and year-specific variation not explained by the model.

A textbook DiD writes the model with separate main effects for Treatment and Post alongside their interaction. With panel data, both main effects are redundant. Treatment status does not change over time for any parcel, so the parcel fixed effect already absorbs it. Post is a step

function of year, so the year fixed effect already absorbs it. Only the interaction (Treatment × Post) varies independently, and that is the term the script retains. The DiD parameter β_3 is numerically identical to the textbook formulation and the fixed effects version is simply more efficient.

Parallel Trend

DiD identifies the causal effect of the RCUT only if treatment and control parcels were on the same valuation trajectory before installation. A separate regression is estimated on pre-period observations only to test this:

$$\log(V_{it}) = \alpha_i + \delta_t Year_t + \delta_2 (Treatment_i * Year_t) + u_{it} \quad \text{Equation 3}$$

δ_2 is the parameter of interest. It measures whether treatment and control parcels had different annual valuation trends during the pre-period. If the p-value on δ_2 falls below 0.10, the parallel-trends assumption is flagged as violated. DiD subtracts out any preexisting level difference between the two groups, however, it cannot subtract out a pre-existing slope difference. A flagged pair's DiD estimate is still reported, but it is treated as directional evidence rather than a clean causal estimate.

Residential and Commercial Subgroup Analysis

The primary DiD is refit on residential parcels and commercial parcels separately, both pooled across the four primary pairs and on a per-pair basis. The specification is identical to Step 3.5.3; the only change is that the estimation sample is restricted to parcels with a tax class code beginning with R (residential) or C (commercial). The pooled corridor effect can be close to zero while residential and commercial parcels move in opposite directions underneath that average.

Secondary Pairs Estimator

For the four secondary pairs, the adjacent-parcel sample yields only five to seven parcels per side, which is too few for parcel fixed effects. A four-step procedure is used instead.

Step 1) Per-parcel log change. For each parcel i , compute:

$$\Delta_i = \log(V_{ipost}) - \log(V_{ipre}) \quad \text{Equation 4}$$

This is the parcel's approximate percentage change in value over the study window. Collapsing each parcel to a single change score converts the panel into a cross-section, which is what the small sample requires.

Step 2) : Average the per parcel changes within each arm. Let T denote the treatment parcels and C the control parcels, with n_t and n_c parcels respectively:

$$\overline{\Delta_T} = \left(\frac{1}{n_T}\right) \sum_{i \in T} \Delta_i \quad \text{Equation 5}$$

$$\overline{\Delta_C} = \left(\frac{1}{n_C}\right) \sum_{i \in C} \Delta_i \quad \text{Equation 6}$$

Step 3): The DiD estimator is the difference of the two group means:

$$\beta_{DiD} = \overline{\Delta_T} - \overline{\Delta_C} \quad \text{Equation 7}$$

The estimate is converted to a percent change for reporting. A positive value means treatment parcels appreciated more than control parcels; a negative value means they appreciated less.

Step 4) Welch two-sample t-test (unequal variance) on the two distributions of parcel-level changes:

$$t = \frac{\overline{\Delta_T} - \overline{\Delta_C}}{\sqrt{\frac{s_T^2}{n_T} + \frac{s_C^2}{n_C}}} \quad \text{Equation 8}$$

where s^2 and n are the within-arm variance and sample size. Degrees of freedom follow the Welch-Satterthwaite approximation. The Welch version is used rather than Student's t because the treatment and control arms can have very different variances when the sample is small.

Buffer Sensitivity Check

The primary DiD use a 0.5-mile (~800ft) buffer. To enable a like-for-like cross-method comparison with the VIIRS analysis, the primary DiD is re-estimated on subsets of parcels within 330ft, 1640ft, and 2640ft of the intersection using geocoded parcel coordinates.

A real intersection effect should fade as you move farther from the node. A signal that grows with buffer distance points instead to a corridor-wide trend. Running the DiD at multiple buffers distinguishes between these two mechanisms and creates an apples-to-apples comparison with the VIIRS results, which utilizes 0ft, 330ft, and 1640ft buffers.

VIIRS Nighttime Lights

Nighttime radiance from the VIIRS satellite serves as a high-frequency proxy for local economic activity. Commercial and industrial operations generate artificial light; changes in radiance intensity at a specific location over time can reflect changes in the level of economic activity

there. VIIRS picks up patterns that annual property assessments cannot, because assessments update only once a year and trail the market by at least one cycle.

Radiance Panel Construction

Monthly VIIRS radiance is extracted for each primary intersection and its matched control at three buffer radii. The variable R_{ijt}^{ljt} denotes the mean radiance at site j inside buffer i during month t , measured in nanowatts per square centimeter per steradian ($\text{nW cm}^{-2} \text{sr}^{-1}$). The native VIIRS pixel is approximately 1519ft, so the 0ft and 330ft extracts fall within the same pixel and return nearly identical values. The 1640ft buffer is the first that reaches into adjacent pixels and captures a small surrounding area.

Seasonal Adjustment

Before any trend model is fit, the twelve-month radiance cycle is removed. Nighttime radiance has a strong annual pattern driven by leaf cover, snow cover, atmospheric haze, and night length. The amplitude of that cycle is on the same order as the post-installation effect we are looking for. If the cycle is not removed, a pre-versus-post comparison would largely reflect which calendar months happened to fall in each window rather than any RCUT effect.

The seasonal adjustment subtracts each observation's long-run site-buffer-month mean:

$$R_{ijt}^{sa} = R_{ijt} - \bar{R}_{ij, m(t)}$$

$$R_{ijt}^{SA} = R_{ijt} - \overline{R_{ij, m(t)}} \quad \text{Equation 9}$$

where $\bar{R}_{ij, m(t)}$ is the mean radiance at site j inside buffer i averaged across all years for the calendar month of observation t , and $m(t)$ takes integer values 1 through 12. This within-site,

within-month demeaning removes the seasonal cycle while keeping the level structure of each site intact.

Modified Interrupted Time Series (MITS)

MITS is used rather than a simple pre and post mean comparison because monthly radiance carries a continuous background trend that would otherwise be mistaken for a treatment effect. MITS accounts for three things simultaneously: any pre-period level difference between sites, any pre-period slope difference, and any post-period change in slope or level. Pulling those apart matters because a level jump and a slope change have different policy meanings, a level jump suggests a one-time reorganization of activity, while a slope change suggests an ongoing trajectory shift.

The installation calendar year is excluded from both the pre and post windows to prevent construction noise from contaminating either period. The model is:

$$\begin{aligned}
 R_{jt}^{SA} = & \beta_0 + \beta_1 Treatment_j + \beta_2 t + \beta_3 (t * Treatment_j) + \beta_4 Post_t & \text{Equation 10} \\
 & + \beta_5 (Post_t * Treatment_j) + \beta_6 t^{post} t \\
 & + \beta_7 (t^{post} t * Treatment_j) + \varepsilon_{jt}
 \end{aligned}$$

In this specification, R_{jt}^{SA} denotes the seasonally adjusted nighttime-lights radiance at site j in month t , serving as the remote-sensing proxy for commercial activity. The indicator $Treatment_j$ equals one for the RCUT site and zero for its matched control, while $Post_t$ equals one for months after the installation year and zero before. Two time variables capture the temporal structure of the panel: t is a continuous month index running from the start of the observation period, which accounts for any pre-existing drift common to both sites, and t^{post} is the number of months

elapsed since installation, set to zero throughout the pre-period and then incremented as 1, 2, 3, and so on afterward. The model decomposes the treatment response into distinct components. The coefficient β_3 , on the interaction of t with Treatment_j , measures the difference in pre-period slope between the treatment and control sites and serves as the parallel-trends diagnostic; it should be close to zero, and a value significant at $p < 0.10$ flags a potential violation. The coefficient β_5 , on the interaction of Post_t with Treatment_j , captures the immediate level shift at the treatment site relative to its control at the time of installation. The headline coefficient, β_7 , on the interaction of Post_t with Treatment_j , measures the differential post-installation slope change at the RCUT site relative to its control: a positive value indicates that radiance grew faster at the treatment site after installation, whereas a negative value indicates slower growth or decline. The remaining coefficients ($\beta_0, \beta_1, \beta_2, \beta_4, \beta_6$) establish the corresponding baseline level and slope terms for each main effect, and ε_{jt} is the residual error.

Parallel-Trends Diagnostic

β_3 , the coefficient on the interaction between site type and the continuous pre-period time trend is the parallel-trends diagnostic for the MITS model. It measures whether treatment and control sites had different pre-period radiance slopes. If they did, any post-period slope difference captured by β_7 could be a continuation of the prior gap rather than an RCUT effect. Because the MITS regression already estimates β_3 , the parallel-trends test is available at no additional cost. Pairs where the p-value on β_3 falls below 0.10 are flagged as violated at that pair and buffer; their β_7 estimates are reported as directional rather than causal evidence. This is the same threshold and interpretation as the property value parallel-trends test.

Companion Pre/Post Gap Test

Alongside MITS, a simpler estimator is run as a robustness check that imposes no parametric trend assumptions. For each month, the treatment-minus-control radiance gap is computed:

$$G_t = R_{T,t}^{sa} - R_{C,t}^{sa} \quad \text{Equation 11}$$

The gap series is then split into pre- and post-installation months, and a Welch two-sample t-test tests whether the mean gap shifted between the two periods:

$$t = \frac{\bar{G}_{post} - \bar{G}_{pre}}{\sqrt{\frac{s_{post}^2}{n_{post}} + \frac{s_{pre}^2}{n_{pre}}}} \quad \text{Equation 12}$$

where $\bar{G}$ and s^2 are the period means and variances of the gap series, and n is the number of months in each period. MITS is a parametric model with seven coefficients, if it is mis specified. For example, if the post period trend is not linear, the β_7 can be biased. The gap t-test makes far weaker assumptions. When MITS and the gap test agree on direction and significance, the result is considered robust. When they disagree, the MITS estimate is preferred because it explicitly controls for the pre-existing trend, but the disagreement is flagged in the results.

Seasonal Decomposition (Supporting View)

As a non-parametric visual confirmation of the MITS results, an additive seasonal decomposition is applied to each radiance series:

$$R_{jt} = Trend_{jt} + Seasonal_{jt} + Residual_{jt} \quad \text{Equation 13}$$

Pre-period and post-period linear slopes are then fit to the trend component for each site, and the slope change is reported for the treatment and control arms separately. The seasonal decomposition does not impose a linear or parametric form, so it acts as an independent check on the MITS regression. If the seasonal decomposition trend lines diverge sharply at the installation date for a pair where MITS finds a small effect, that mismatch is worth investigating. This step provides a visual confirmation, not a headline test.

Buffer Dilution Check

The absolute value of β_7 from MITS is plotted at 0ft, 330ft, and 1460ft for each pair. A real RCUT effect at the intersection should be largest at the node itself and attenuate as the buffer expands, because farther out pixels include more land unaffected by the corridor change. A signal that grows with buffer distance instead points to something happening across the corridor. The buffer dilution plot makes this distinction visible and is reported alongside the primary MITS coefficient table.

Differences Between the DiD and MITS Approaches

The property value analysis uses a panel DiD because county assessor records provide one valuation per parcel per year, (typically five to ten observations per parcel across the study window). That cadence is too sparse to fit a time-series model at the parcel level, but numerous enough across thousands of parcels within a 0.5-mile buffer to run a fixed effects panel regression. The VIIRS data, by contrast, are monthly composites that yield roughly 100 observations per site, well suited to a time-series approach. Both methods use the same identification logic: compare the treatment trajectory to a matched control and attribute any divergence that begins at the installation.

Cross-Method Triangulation

Results across the four data streams are synthesized by comparing the direction and significance of each method's estimate for the same pair. Conclusions about economic impact are drawn only when at least two independent methods agree in direction.

Annual Property Value and VIIRS Radiance Correlation

For each pair, annual mean log valuation and annual mean VIIRS radiance at the 330ft buffer are computed, then the Pearson and Spearman correlations between the two series are estimated.

The Pearson correlation is:

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}} \quad \text{Equation 14}$$

The Spearman correlation applies the same formula to the ranks of x and y rather than the raw values. Both correlations are also computed on the treatment-minus-control annual gap series, rather than the raw levels. The levels correlation is dominated by long-run shared trends that affect both property values and radiance when the regional economy grows. The gap version strips that shared trend out, because the control absorbs whatever happens regionally. A correlation that survives in the gap series is much more likely to reflect an RCUT-specific signal than the raw-levels correlation.

Sign-Agreement Scatter

One point per pair is plotted on a two-axis scatter with the property DiD percent change on the horizontal axis and the VIIRS MITS coefficient at 330ft on the vertical axis. Reference lines at zero create four quadrants

1. Upper right: both methods positive: commercial gain corroborated by both.
2. Lower left: both methods negative: decline corroborated by both.
3. Upper left or lower right: methods disagree on direction.

The two methods measure different things. Property values move slowly and capture appraised market position; radiance moves monthly and captures real-time activity. Asking them to give the same numerical answer is unrealistic. Asking them to agree on direction is reasonable. The sign-agreement scatter shows which pairs have two methods telling the same story and which have one method going its own way.

Matched-Buffer Cross-Method Comparison at 1640ft

A pair that disagrees in the headline scatter might still agree if both methods are placed on the same buffer. The matched buffer check re-estimates both methods at 1640ft and compares the results:

1. Property DiD at 1640ft: from the buffer sensitivity analysis.
2. VIIRS MITS at 1640ft: from the primary MITS results.
3. Each pair is tagged as Agree or Disagree based on the sign of the two estimates.

When two methods agree at a matched spatial scale, that is the strongest single-pair evidence the study can produce. The matched 1640ft read separates genuine cross-method disagreement from buffer asymmetry and is the benchmark used to assess each pair's overall evidence classification.

CHAPTER 4. ACCESSIBILITY STUDY

This chapter presents the accessibility framework used to evaluate RCUT installations in Georgia. The companion safety analysis - a matched treatment-and-control difference-in-differences specification on yearly GDOT crash counts - is reported separately in **Appendix D**.

4.1 ACCESSIBILITY ANALYSIS

Spatial Framework

A typical RCUT intersection is formed by the crossing of a major road and a minor road. As shown in **Figure 1**, these two roads divide the surrounding area into four quadrants: Northeast, Northwest, Southeast, and Southwest. These quadrants serve as the spatial categories for evaluating the impact of access restrictions and detours on adjacent businesses. Each quadrant's exposure to accessibility loss depends on which approach directions are affected by the RCUT geometry and whether the minor road continues as a live through-street or terminates within a commercial plaza with internal circulation.

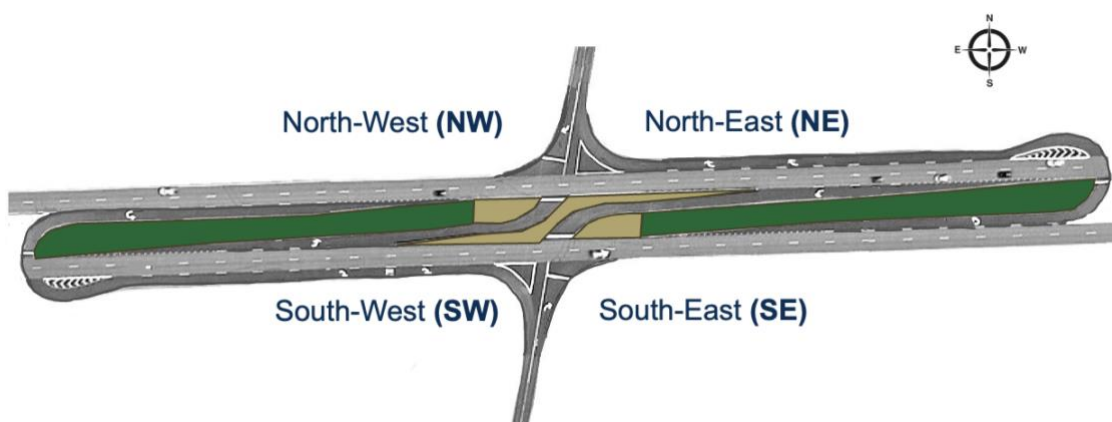


Figure 1: Diagram. Four Quadrant Areas of an RCUT Intersection

Route Scenarios

For any business located within a quadrant, customer vehicles can arrive from multiple directions via multiple maneuver types. Combining the four cardinal approach directions with the four possible maneuver types: through, right turn, left turn, and U-turn, produces 16 core route scenarios representing all possible ways a vehicle can approach and enter a business. Under RCUT geometry, each scenario is classified as Permitted, Prohibited, or Rerouted, as shown in

Table 5. All accessibility loss is concentrated in the four minor-road cross and left-turn movements; all major-road movements retain full access.

Table 5: Vehicle Movement Restriction Under RCUT Configuration

Movement Type	Direction	RCUT Status
Through	West → East	Permitted
Through	North → South	Prohibited
Through	East → West	Permitted
Through	South → North	Prohibited
Right turn	West → South	Permitted
Right turn	North → West	Permitted
Right turn	East → North	Permitted
Right turn	South → East	Permitted
Left turn	West → North	Permitted
Left turn	North → East	Prohibited
Left turn	East → South	Permitted
Left turn	South → West	Prohibited
U-turn	West → West	Permitted

U-turn	North → North	Rerouted
U-turn	East → East	Permitted
U-turn	South → South	Rerouted

Data Collection

A variety of data sources are used to populate the accessibility framework. Metrics are organized into quantitative inputs, which feed directly into the decay equation, and qualitative inputs, which characterize the site context and moderate how accessibility loss translates into economic impact.

Qualitative Metrics

Signalization Status:

Whether an RCUT is signalized or unsignalized affects the level of access friction imposed on minor-road movements. At unsignalized RCUTs, vehicles completing the required U-turn maneuver do so under yield conditions, adding variable delay that is not captured by geometric distance alone. Signalization status is recorded for both the RCUT node and the nearest downstream U-turn crossover.

Pedestrian Infrastructure:

The presence or absence of sidewalks, crosswalks, and bicycle lanes along the minor road determines whether non-motorized users retain meaningful access to adjacent businesses after RCUT installation. Sites with no pedestrian infrastructure impose a complete access barrier on walking and cycling trips that the geometric decay model does not capture and are flagged for enhancement review under Rule 4 of the implementation guidelines.

RCUT Signage:

The current GDOT standard for RCUT intersections focuses on traffic control and driver compliance, prohibiting illegal movements and directing drivers through the required right-turn and U-turn path, but provides limited destination guidance for customers approaching from the minor road. This can be seen in **Figure 2**, drivers in many cases encounter a restriction without clear wayfinding to the nearest U-turn crossover, which is a relevant context factor for high-impulse businesses that depend on spontaneous customer decisions.

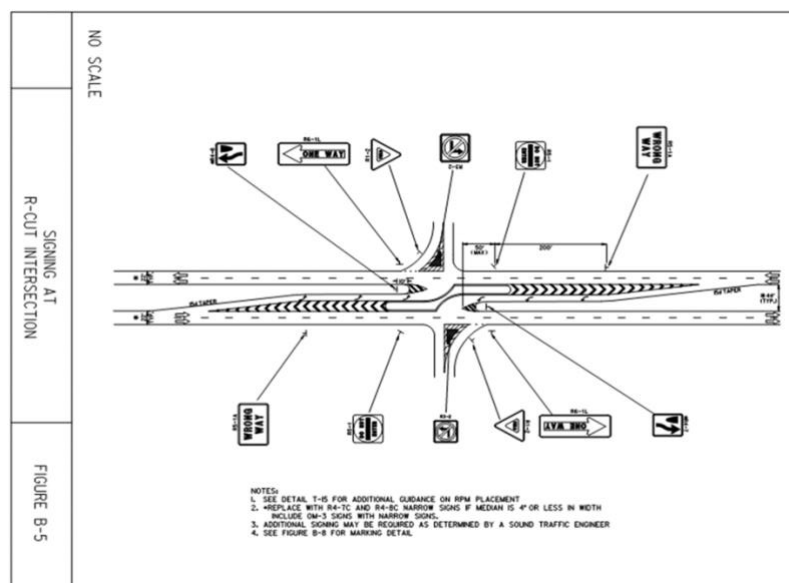


Figure 2: Diagram. Georgia Department of Transportation Signage and Marking Design Guidelines

Quantitative Metrics

Intersection Coordinates:

The latitude and longitude of the RCUT node serve as the geographic anchor for all spatial measurements in the analysis. Coordinates are used to delineate the four quadrants, define buffer boundaries, and locate U-turn crossover relative to the intersection.

AADT (Major and Minor Road):

Average Annual Daily Traffic counts provide the baseline vehicle volume assigned to each of the 16 route scenarios. Major and minor road AADT are retrieved from the GDOT TADA database; where intersection-level counts are unavailable, the nearest arterial segment count is used as an approximating indicator.

Turning Movement Counts:

Directional turning movement counts apportion segment-level AADT to individual route scenarios. Where GDOT project files do not include turning movement data, counts are collected through short-duration drone or camera observation during peak periods.

U-turn crossover Locations and Distances:

The distance from the minor road stop bar to the nearest available U-turn crossover is the primary driver of out-of-direction (increased) travel distance in the decay equation. Bay locations are identified through aerial imagery and verified in the field using GPS measurement.

Pre-RCUT Route Distances (16 Scenarios):

The direct-path travel distance for each of the 16 route scenarios under conventional intersection geometry establishes the pre-installation baseline. Where historic aerial imagery is available in Google Earth Pro, pre-RCUT conditions are verified before measurement.

Post-RCUT Route Distances (16 Scenarios):

For prohibited or rerouted movements, the post-RCUT distance traces the actual detour path from the minor road approach through the nearest U-turn crossover back to the destination quadrant. The travel distance d is the difference between the post- and pre-RCUT measurements.



Figure 3: Screenshot. Pair 90 Post RCUT Northbound detour (0.62 miles)



Figure 4: Screenshot. Pair 90 Post RCUT Southbound detour (0.25 miles)

Business Inventory:

A land-use inventory of all businesses within the 0.5-mile buffer of each quadrant documents business name, address, quadrant assignment, and vulnerability tier. Tier classification determines the baseline entry probability p applied in the decay equation.

Number of Through Lanes:

The cross-section geometry of the major road affects U-turn crossover accessibility and the total detour distance drivers must navigate. Lane count is recorded from Google Maps satellite imagery and verified during field visits.

Posted Speed Limit (Minor Road):

The minor road speed limit provides operational context for interpreting geometric delay distance, as higher speeds reduce the relative cost of short detours while increasing the penalty for longer ones.

Analytical Method

The customer entry decay framework quantifies the reduction in impulsive stop probability caused by RCUT-imposed detours. In its baseline form, the framework assigns a fixed entry probability p to each business based solely on its vulnerability tier: HIGH-tier businesses (gas stations, fast food, convenience stores) receive $p = 0.20$, MEDIUM-tier businesses receive $p = 0.10$, and LOW-tier businesses receive $p = 0.03$. While this tier structure provides a defensible and internally consistent starting point, it does not distinguish between quadrants whose land-use composition differs substantially.

The ITE-calibrated methodology replaces the uniform tier assignment with a site- and quadrant-specific baseline probability p^i derived from the actual mix of businesses observed in each quadrant. Rather than assuming every HIGH-tier quadrant carries the same baseline, this approach weights each business's empirically documented pass-by capture rate by the traffic-generating intensity of its land use category. The result is a dimensionless entry probability that reflects the behavioral reality of the specific commercial environment surrounding each RCUT intersection.

This refinement does not alter any other element of the decay equation. The coefficients $k_d = 0.50$ per mile and $k_t = 0.30$ per extra turn, the travel distance d_i , the turn penalties t_i , and the directional AADT inputs remain unchanged. The only substitution is that p^i replaces the fixed tier value of p in the impulsive entry probability equation:

$$n_i = p^i e^{(-k_d d_i - k_t t_i)} \quad \text{Equation 15}$$

$$E_i = AADT_i * n_i \quad \text{Equation 16}$$

The pre-RCUT baseline for any route is $n_i = p^i$ with $d_i = 0$ and $t_i = 0$. Permitted movements after RCUT installation retain this baseline unchanged. The decay penalty applies exclusively to the four prohibited minor-road movements.

Step 1: Business Inventory and ITE Code Matching

For each of the four quadrants (NE, NW, SE, SW) at a given RCUT site, a land-use inventory is compiled using Google Earth Pro aerial imagery, Google Maps place data, and county business license records. Each identified business j in quadrant q is assigned an ITE Land Use Code from the ITE Trip Generation Manual and the corresponding PM peak hour trip rate (TPM^i) and pass-by capture rate (PB^i) are recorded from the Manual's land use code tables [16]. Pass-by capture rates for gas station and convenience store categories are supplemented by the ITE pass-by studies, which reports an average rate of 56% for ITE Code 945 (Gasoline/Service Station with Convenience Market) across 9 empirical studies with a range of 46 to 72%. For land use types not covered, pass-by rates are drawn directly from the ITE TGM or, for categories not updated in the ITE TGM, these estimates are taken from Gluck et al [17], which remains the standard access

management reference for pass-by rate estimation. As seen in **Table 6**, rates are expressed as decimals for use in Step 2.

Table 6: Pass-By Trip Rates by Business Type and ITE Land Use Codes

Business Type	ITE Code	PB ⁱ (decimal)	n Studies	Source
Gas/Convenience Store	945	0.56	9	ITE TGM / WisDOT
Convenience Store (standalone)	851	0.51	11	ITE TGM 11th Ed.
Fast Food w/ Drive-Through	934	0.45	-	Gluck et al. Table 66
Fast Food w/ Drive-Through (no indoor seating)	935	0.41	-	ITE TGM 11th Ed.
Supermarket	850	0.36	12	ITE TGM 11th Ed.
Small Retail < 50,000 sf	820	0.55	-	Gluck et al. Table 66
Shopping Center 50k–100k sf	820	0.45	-	Gluck et al. Table 66
Shopping Center 250k–500k sf	820	0.30	-	Gluck et al. Table 66
High Turnover Sit-Down Restaurant	932	0.40	-	Gluck et al. Table 66
Medical/Dental Office	720	0.08	-	ITE TGM (low-impulse assumption)
General Office	710	0.05	-	ITE TGM (low-impulse assumption)
Residential parcel	-	1.00	-	Deterministic (report assumption)

Step 2: Trip-Rate-Weighted Pass-By Probability per Quadrant

For each quadrant q , the baseline entry probability p^i is computed as a weighted average of the ITE pass-by capture rates across all businesses in that quadrant. Each business is weighted by its ITE PM peak hour trip rate TPM^i , reflecting the relative traffic-generating intensity of each land

use type. Building size is not incorporated because the objective is to estimate a dimensionless entry probability at the quadrant level rather than an absolute trip count. The PM peak hour trip rate serves as a sufficient proxy for relative importance: a fast-food drive-through generating 33 trips per standard unit naturally exerts greater influence on the quadrant's baseline probability than a medical office generating 4 trips per unit, without requiring field measurement of floor area.

The quadrant-level baseline entry probability is computed as:

$$p_i = \frac{\sum PB^i * TPM^i}{\sum^i (TPM^i)} \quad \text{Equation 17}$$

Where PB^i is the pass-by capture rate for business j drawn from **Table 1**, and TPM^i is the ITE PM peak hour trip rate per unit for business j drawn from the ITE TGM 11th Edition. The summation runs over all businesses j assigned to quadrant q . This weighting scheme is preferable to a simple unweighted average because it prevents low-traffic businesses from diluting the probability estimate in quadrants dominated by high-impulse land uses. A quadrant containing a single gas station and five professional offices should reflect the behavioral dominance of the gas station in determining how likely a passing driver is to make a spontaneous stop, and the PM peak hour trip rate achieves this without introducing additional data requirements.

Worked Example

To illustrate the calculation, consider a hypothetical NE quadrant containing four businesses. The ITE code, pass-by rate, and PM peak hour trip rate for each business is drawn from **Table 6** and the ITE TGM 11th Edition, respectively. **Table 7** presents the weighted computation.

Table 7: Pass-By Trip Exposure by Business Type

Business	ITE Code	PBⁱ	TPMⁱ (trips/unit)	PBⁱ × TPMⁱ
Gas/Convenience Store	945	0.56	13.91	7.79
Fast Food w/ Drive-Through	934	0.45	33.03	14.86
High Turnover Sit-Down Restaurant	932	0.40	9.05	3.62
Medical-Dental Office	720	0.08	3.93	0.31
Totals			59.92	26.58

$$p^i(NE) = 26.58 / 59.92 = 0.443$$

The fast-food drive through dominates the numerator despite comprising only one of four establishments, because its trip rate of 33.03 is approximately 8.4 times that of the medical office at 3.93. This reflects the behavioral logic underlying the methodology: quadrant entry probability should be driven by the land uses that attract impulsive passing traffic, not by a simple count of establishments.

Step 3: Quadrant Assignment and Directional Logic

Steps 1 and 2 are executed independently for all four quadrants at each site, producing four quadrant-specific baseline probabilities: $p^i(NE)$, $p^i(NW)$, $p^i(SE)$, and $p^i(SW)$. These values are not combined or averaged across quadrants. Multiplying quadrant probabilities would produce a joint probability representing the likelihood that a vehicle enters businesses in multiple quadrants simultaneously, which is not the phenomenon of interest. Averaging across the north or south side would obscure directionally asymmetric land use compositions that are precisely what the methodology is designed to detect.

Each of the 16 route scenarios is assigned the baseline probability of the quadrant whose businesses are accessible from that approach direction. The directional assignment logic follows

the spatial framework established in Chapter 4. Vehicles traveling southbound on the major road pass NW and NE quadrant businesses, so those routes use $p^i(\text{NW})$ or $p^i(\text{NE})$ respectively.

Vehicles traveling northbound pass SE and SW quadrant businesses, using $p^i(\text{SE})$ or $p^i(\text{SW})$.

Minor-road approaches draw on the quadrant from which they originate. **Table 8** summarizes the quadrant assignment by approach direction.

Table 8: Pass-By Exposure by Travel Direction and Quadrant

Vehicle Traveling...	Passes Businesses In...	Baseline Probability Used
South → North (minor road, through/left)	NE and NW quadrants	$p^i(\text{NE})$ or $p^i(\text{NW})$
North → South (minor road, through/left)	SE and SW quadrants	$p^i(\text{SE})$ or $p^i(\text{SW})$
West → East (major road)	NE and SE quadrants	p^i of destination quadrant
East → West (major road)	NW and SW quadrants	p^i of destination quadrant

Step 4: Applying the Decay Equation with Quadrant-Specific p

With quadrant-specific baseline probabilities established, the decay equation is applied identically to the procedure described in Chapter 4, substituting p^i for the tier-fixed value of p .

For each of the 16 route scenarios at the intersection, the impulsive entry probability and estimated customer entry volume are computed using Equation 14 and Equation 23.

For all permitted routes, $d_i = 0$ and $t_i = 0$, so $n_i = p^i$ and the full baseline entry volume is retained. For the four prohibited minor-road movements, the decay penalty applies with $k_d = 0.50$ per mile and $k_t = 0.30$ per extra turn. The pre-RCUT baseline for each route is $E_i = \text{AADT}_i \cdot p^i$ with $d_i = 0$ and $t_i = 0$. The site-level pre- and post-RCUT customer entry volumes are obtained by summing across all 16 routes:

$$\Delta E_{site} = \sum E_i^{pre} - \sum E_i^{poyt} \quad \text{Equation 18}$$

This difference represents the net estimated daily customer entry vehicle loss attributable to RCUT geometry at the site, disaggregated by quadrant so that directional and spatial asymmetries in access burden can be identified and reported.

Step 5: Sensitivity Comparison with Tier-Fixed Baseline

To evaluate the sensitivity of the results to the choice of baseline specification, both the ITE-calibrated quadrant probability p^i and the tier-fixed baseline p are applied at each study site. Where the two specifications diverge by more than 10 percentage points, the ITE-calibrated value is used in the primary analysis, and the tier-fixed value is reported as a lower-bound sensitivity estimate. This approach acknowledges that the ITE-calibrated values will generally be higher for gas station and fast food-dominated quadrants, because the adjusted pass-by rate of 56% for ITE Code 945 substantially exceeds the HIGH-tier fixed assumption of 20%.

The ITE-calibrated values represent a more conservative estimate of accessibility loss only in the mathematical sense that the pre-RCUT baseline is higher; the proportional decay imposed by a given detour distance remains the same under both specifications. The practical implication is that in quadrants with predominantly high-impulse land uses, the absolute volume of customers at risk of diversion is larger than the tier-fixed baseline suggests, and the site-level ΔE estimate will reflect this more precisely.

The comparison between specifications is presented in the results tables as shown in **Table 9** with the ITE-calibrated value as the primary column and the tier-fixed value as the sensitivity column.

Table 9: ITE vs. Tier-Fixed Pass-by Probability Comparison by Quadrant

Quadrant	ITE-Calibrated (primary)	p ⁱ	Tier-Fixed (sensitivity)	p	Divergence (pts)	Flag
NE	0.44		0.20		24	Flag: ITE primary
NW	0.38		0.20		18	Flag: ITE primary
SE	0.22		0.20		2	Within threshold
SW	0.10		0.10		0	Within threshold

CHAPTER 5. QUALITATIVE SURVEY

This chapter presents the qualitative survey component of the study. The chapter begins with survey design, describing the survey instrument, the rationale for question ordering with respect to priming concerns, and the block structure for business and resident/patron respondents.

Sample and Data Processing follows, documenting the respondent classification rules. The chapter then presents the statistical methods used to analyze the responses, including the Pearson chi-squared test of independence, the Cochran threshold and Fisher exact fallback, Cramer's V effect size, Wilson 95% confidence intervals for proportions, and Spearman rank correlation.

The objectives of this chapter are as follows:

1. Design and administer a two-path intercept survey instrument deployed across three Georgia RCUT corridors, with question ordering structured to isolate unprompted access, congestion, and safety perceptions prior to any RCUT-specific framing, in accordance with established survey priming protocols.
2. Characterize business-side economic perceptions at sampled RCUT sites through quantitative items on revenue direction, customer volume, vehicle access ease, and operational

adjustments, and validate internal consistency between revenue and volume responses using Spearman rank correlation and chi-squared independence tests.

3. Characterize resident and patron perceptions of corridor safety, congestion change, and access behavior across the three study sites, and evaluate whether perception distributions differ significantly between respondent groups using chi-squared tests with Fisher exact fallback and Cramér V effect size reporting.
4. Identify and interpret the perception gap between worsened congestion perception and stable-to-positive economic outcomes across business and resident samples and situate that gap within the broader multi-method project finding that anticipated economic harm at RCUT corridors exceeds realized harm.

5.1 SURVEY DESIGN

The survey was administered through Qualtrics in five sequential blocks. The first block handled IRB consent and screened out any respondent who declined. A short screener in the second block routed each respondent to one of two parallel paths based on their relationship to the site. Both paths converged into a shared general block of twelve items addressing navigation habits, impulse stops, access willingness, safety, and stated preference tradeoffs across RCUT awareness. A surveyor-only tagging block closed the instrument. The sales item appeared only for business interviewees.

Survey Paths: Path A and Path B

The survey was divided into two paths: Path A and Path B. Path A is structured for business owners and managers, with questions pertaining to business health, customer volume, and

revenue. It contained nineteen items covering customer volume, revenue, vehicle access, operating hours, congestion, safety, and free-response prompts on driver behavior and recommendations. Path B is designed for community members who patronize these businesses, with questions specific to safety, route familiarity, and their experience accessing the business location. It targeted patrons, residents, and commuters and contained eleven items covering travel mode, area familiarity, trip planning, route choice, congestion, and safety. Path B makes no mention of RCUTs until the final shared block, which lets community respondents characterize their access experience, travel behavior, and safety perceptions in their own terms before any intersection-specific stimulus is introduced. This is shown in **Table 10**.

5.2 QUESTION ORDERING AND THE PRIMING CONCERN

The most consequential decision in instrument design was question ordering. All items that explicitly referenced RCUTs by name, including the intersection geometry diagrams in the shared general block, were placed at the end of the instrument so that respondents completed every general access, traffic, and business performance item before encountering any RCUT-specific framing. Prior research on alternative intersection designs has consistently shown that public perception of these designs is more negative before construction than after, once users have direct experience with the design [8].

A pilot administration of an earlier version of this instrument confirmed the same pattern in the present study. Respondents who encountered RCUT-specific framing and imagery in the opening blocks responded uniformly negatively across all subsequent questions, with little variation by site, business type, or respondent role. The pilot data suggested those responses reflected a generalized aversion to an unfamiliar intersection design rather than any considered reaction to

behavioral or economic changes at the actual sites. The instrument was revised to remove all RCUT-specific language, images, and framing from the opening blocks.

Table 10: Survey Instrument Structure and Routing by Respondent Path

Block / Path	Type	Question Number	Purpose
Path A/B Screener	All respondents	Questions 1-3	Role, tenure, visit frequency; used to route to Path A or B
Path A: Business / Employees	Owners, managers, employees	Questions 5-24 (19 items)	Customer volume, revenue, access ease, operational changes, safety, open-ended recommendations
Path B: Community / Patrons	Patrons, residents, commuters	Questions 44, 48, 25-28, 30, 32-33, 49, 35 (11 items)	Mode, familiarity, trip planning, congestion, safety, open-ended navigation issues

5.3 BLOCK AND PATH SUMMARY

Sample and data processing

Responses were collected at three RCUT corridors through a combination of in-person intercept surveys, business owner outreach, and Qualtrics QR code distribution. The cleaned dataset contains 102 responses after dropping 7 nonconsenting respondents and 1 data entry error from a raw collection of 110. Respondents split into 38 business and 59 resident or patron entries, with 5 records that could not be classified by respondent type.

By site, 43 responses came from RCUT 5 (south of Atlanta; plaza-constrained, signalized, with a pedestrian crossing on the major road), 43 came from RCUT 91 in Alto (north of Atlanta; free-flow minor road, unsignalized, no pedestrian crossing on the major road), and 15 came from RCUT 4 (south of Atlanta; plaza-constrained, unsignalized, with no pedestrian crossing on the major road).

Pearson chi-squared test of independence

For an r by c contingency table with observed counts O and expected counts E , the test statistic measures how far the observed cell counts deviate from the counts expected if the two variables were independent.

$$X^2 = \sum (O - E)^2 / E \quad \text{Equation 19}$$

Expected cell counts are obtained from the row totals (R_i), column totals (C_j), and grand total (N).

$$E_{ij} = (R_i * C_j) / N \quad \text{Equation 20}$$

Under the null of independence, the statistic follows a chi-squared distribution with $(r - 1)(c - 1)$ degrees of freedom. The reported p-value is the right tail area beyond the observed value. Yates continuity correction was not applied; the uncorrected statistic is reported throughout.

Cochran threshold and Fisher exact fallback

When any expected cell count is below 5, the chi-squared approximation is unreliable. Following the Cochran rule, two by two tables fall back to Fisher exact, which computes the hypergeometric probability of observing the table or one more extreme conditional on the marginal totals.

$$P = \frac{R_1! R_2! C_1! C_2!}{N! \sum a! b! c! d!} \quad \text{Equation 21}$$

For larger tables with low expected counts, Fisher exact lacks a tractable closed form; the chi-squared statistic is reported with a flag indicating the result is approximate.

Cramer V effect size

A p-value alone does not communicate the strength of association. Cramer V scales the chi-squared statistic by sample size and table dimension, producing a value between 0 (no association) and 1 (perfect association).

$$V = \sqrt{\frac{X^2}{N * \min(r - 1, c - 1)}} \quad \text{Equation 22}$$

Conventional thresholds: $V \approx 0.1$ weak, ≈ 0.3 moderate, ≥ 0.5 strong. Reported alongside every test in Part 3.

Wilson 95% confidence interval for proportions

Headline percent estimates are reported with Wilson confidence intervals, which behave better than the standard Wald interval at small n and proportions near 0 or 1.

$$CI = \hat{p} + \frac{z^2}{2n} + \frac{z}{1 + \frac{z^2}{n}} \sqrt{\frac{\hat{p}(1 - \hat{p})}{n} + \frac{z^2}{4n^2}} \quad \text{Equation 23}$$

$z = 1.96$ for the 95 percent level.

Spearman rank correlation

Likert items recoded onto a numeric ordinal scale are paired with Spearman correlation, which measures monotonic association without assuming linearity.

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad \text{Equation 24}$$

where d_i is the difference between the rank of paired observations. Used here for the revenue and customer volume validity check and for the ordinal correlation matrix across business directional items.

The survey component was originally conducted as part of the broader RCUT evaluation before limitations in parcel sales and property transaction data were fully identified. As the study progressed, the analysis shifted from relying on parcel sales transactions to using assessed property values through a Difference in Differences framework, and VIIRS nighttime light data were incorporated as an additional quantitative measure of economic activity. The survey responses were collected from different RCUT locations than the final property value and VIIRS study sites, they are used as supplementary qualitative evidence rather than as part of the primary causal analysis. The core findings of this study are therefore based on the VIIRS and property value analyses, while the survey results provide supporting context on how residents and businesses perceive changes in access, visibility, traffic flow, and commercial activity following RCUT implementation.

CHAPTER 6. ANALYSIS RESULTS

Chapter 6 reports findings from the four workstreams applied in this study: a difference in differences (DiD) analysis of parcel level assessed property values, a Modified Interrupted Time Series (MITS) analysis of VIIRS nighttime lights radiance, and qualitative survey responses from business owners and area residents at different locations. Eight distinct RCUT and control intersection pairs were evaluated across Georgia. Four primary pairs (63, 79, 88, 90) were analyzed using parcel level property values with a two year pre/post window and a 0.5 mile buffer. Four secondary pairs (14, 53, 71, 93) were analyzed using VIIRS only and a shorter one-year pre/post window with adjacent parcels. The site-level crash analysis, including the treatment-control difference-in-differences results and severity decomposition, is presented in **Appendix D** and is reported separately from the economic impact analysis in this chapter.

6.1 PROPERTY VALUATION ANALYSIS

Primary results

The primary DiD analysis covers 7,023 parcel-year observations across four RCUT pairs. Error! Reference source not found. presents the pre-period parallel trends check for treatment and control parcels, supporting the validity of the design for Pairs 79 and 88 while indicating pre-treatment divergence for Pairs 63 and 90. **Table 11** and **Figure 5** summarize the estimated treatment effects. As shown in Error! Reference source not found., the pooled treatment effect was -2.78%, and the estimate was not statistically different from zero ($p = 0.569$), indicating no evidence that RCUT installation systematically affected these nearby property values overall.

Table 11: DiD Estimates for Property Values by Site Pair and Land Use.

Subgroup	n (parcel-years)	DiD %	p value	Sig
ALL pairs (pooled)	7,023	-2.78%	0.569	ns
Pair 63 (Blairsville) †	1,084	+2.02%	0.763	ns
Pair 79 (Cedartown)	1,165	-1.70%	0.757	ns
Pair 88 (Alto)	1,365	-24.01%	0.013	**
Pair 90 (Warner Robins) †	3,409	-0.54%	0.869	ns
All pairs, Commercial	714	+32.48%	<0.001	***
Pair 63, Residential †	782	+4.08%	0.629	ns
Pair 63, Commercial †	85	+8.31%	0.751	ns
Pair 79, Residential	898	+3.00%	0.347	ns
Pair 79, Commercial	87	-0.34%	0.986	ns
Pair 88, Residential / LI fringe ‡	87	-86.00%	<0.001	***
Pair 88, Commercial §	0	-	-	-
Pair 88, Industrial §	1,190	-6.36%	0.539	ns
Pair 90, Residential †§	2,674	-7.12%	0.015	**
Pair 90, Commercial §	542	+39.82%	0.044	**
Pair 90, Industrial §	181	+9.93%	0.387	ns
All pairs, Residential	4,437	-8.09%	0.352	ns
All pairs, Industrial §	1,384	-12.25%	0.209	ns

Primary property value DiD. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

At the individual pair level, 3 of the 4 RCUT pair level estimates were statistically indistinguishable from zero. The exception was Pair 88, which produced a significant negative estimate of -24% ($p = 0.013$), suggesting a localized decline in adjacent property values following RCUT installation. Parallel trends were assessed using both visual pre-period trend checks and formal pre-trend tests. As seen in **Table 12**, Pair 79 ($p = 0.94$) and Pair 88 ($p = 0.68$) satisfied the parallel trends assumption, supporting stronger causal interpretation of their DiD estimates. In contrast, Pair 63 ($p < 0.001$) and Pair 90 ($p = 0.004$) violated the assumption, indicating that treatment and control parcels were already following different trajectories before RCUT installation. Their estimated treatment effects should therefore be interpreted with caution. Subgroup analysis showed a large positive pooled effect for commercial parcels (+32.48%, $p < 0.001$), however, this result should be interpreted cautiously due to small sample sizes, heterogeneous parcel composition, and limited commercial observations within individual

site pairs. Residential and industrial pooled estimates were not statistically significant. Pair 88 remains the strongest single site finding under the most defensible identification assumptions

Table 12: Pre-Treatment Parallel Trends Check for RCUT Treatment and Control Site Pairs

Pair	Year	Period	Control	Treatment	Diff (T-C)
63 (install 2022)	2020	pre	11.8043	11.5464	-0.2579
	2021	pre	12.1883	11.5906	-0.5977
	2023	post	12.3518	11.9400	-0.4118
	2024	post	12.3618	11.9710	-0.3908
	2025	post	12.3910	11.9925	-0.3985
79 (install 2023)	2021	pre	10.8968	10.8668	-0.0300
	2022	pre	10.9223	10.8847	-0.0376
	2024	post	11.4080	11.3202	-0.0878
	2025	post	11.5369	11.4788	-0.0581
88 (install 2023)	2021	pre	11.4675	11.4772	+0.0097
	2022	pre	11.5508	11.7127	+0.1619
	2024	post	12.3090	12.1211	-0.1879
	2025	post	12.4673	12.3291	-0.1382
90 (install 2023)	2021	pre	11.1037	11.9584	+0.8547
	2022	pre	11.1931	12.0959	+0.9028
	2024	post	11.4748	12.3263	+0.8515
	2025	post	11.5326	12.4405	+0.9079

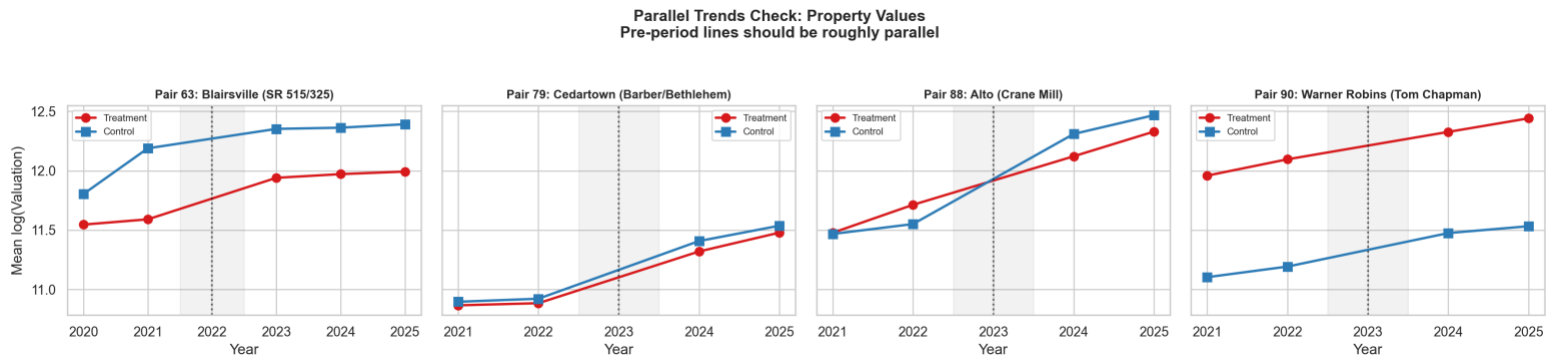


Figure 7: Plots. Parallel trends check showing annual mean log property values for treatment (red) and control (blue) parcels across 4 RCUT site pairs, with the dotted line and grey area marking the RCUT intallation year

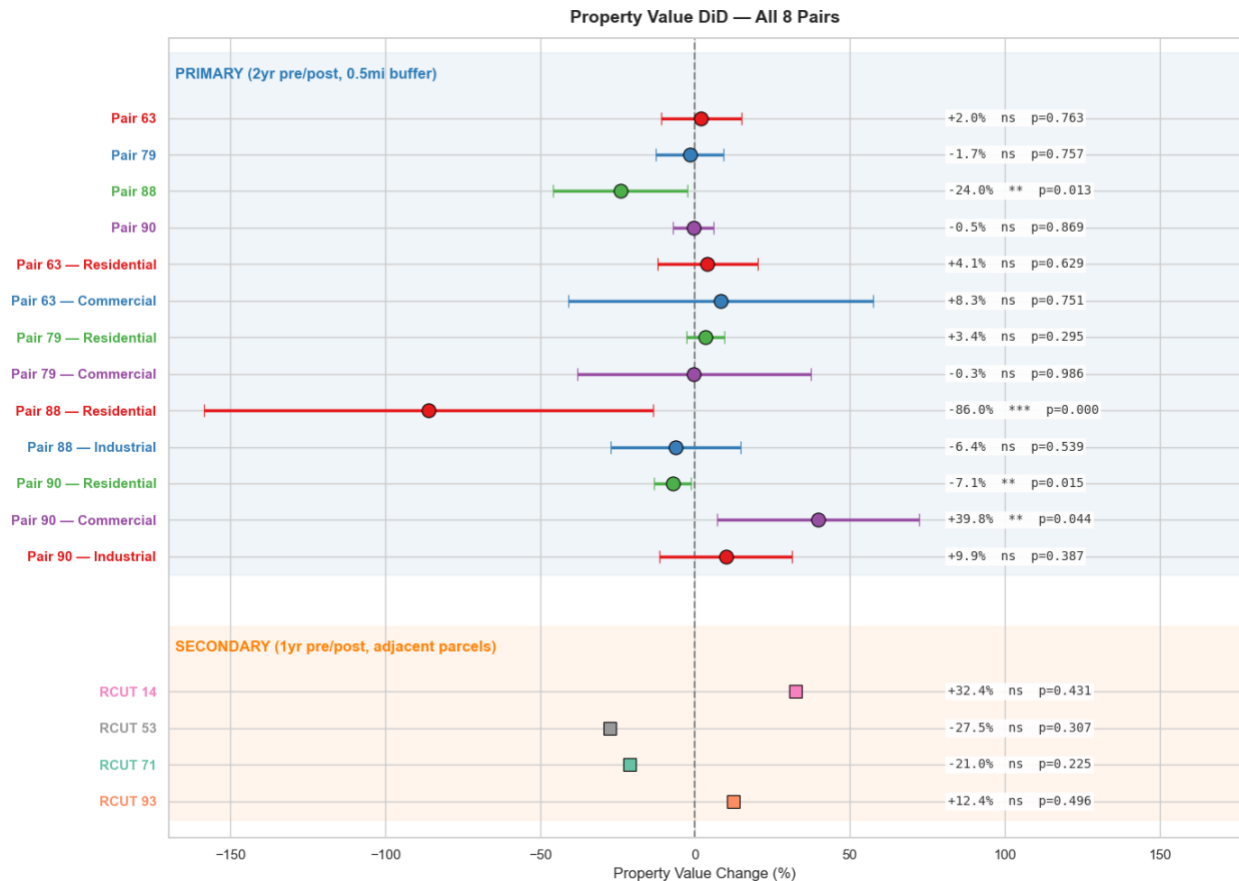


Figure 5: Plot. Forest plot of property value DiD estimates, primary (top block) and secondary (bottom block) pairs. Whiskers show 95% confidence intervals.

Residential and commercial decomposition

The most informative result is the divergence between residential and commercial property values under verified zoning classification. Parcel zoning classifications were rechecked using updated county zoning GIS files. The pooled commercial estimate across the four primary RCUT pairs results in statistically significant at +32.5 percent ($p < 0.001$, $n = 714$), using two-way clustered standard errors at the parcel and pair levels. In contrast, the pooled residential estimate remains negative, but statistically insignificant at -8.1 percent ($p = 0.35$, $n = 4,437$). A pooled industrial subgroup shows a negative but insignificant estimate of -12.3 percent ($p = 0.21$, $n = 1,384$). This pattern of commercial gain and residential decline is concentrated most strongly in

Pair 90. The residential estimate shows a -7.1% decline ($p = 0.015$, $n = 2,674$), while the commercial estimate shows a +39.8% increase ($p = 0.044$, $n = 542$). However, the residential subgroup fails the formal parallel trends test (pre trend $p = 0.016$), which indicates that treatment and control parcels were already following different trajectories before RCUT installation. Pair 88 is characterized by a large residential and light industrial decline of about -86 percent ($p < 0.001$). **Figure 6** shows these pair level estimates and the divergence between residential and commercial property value.

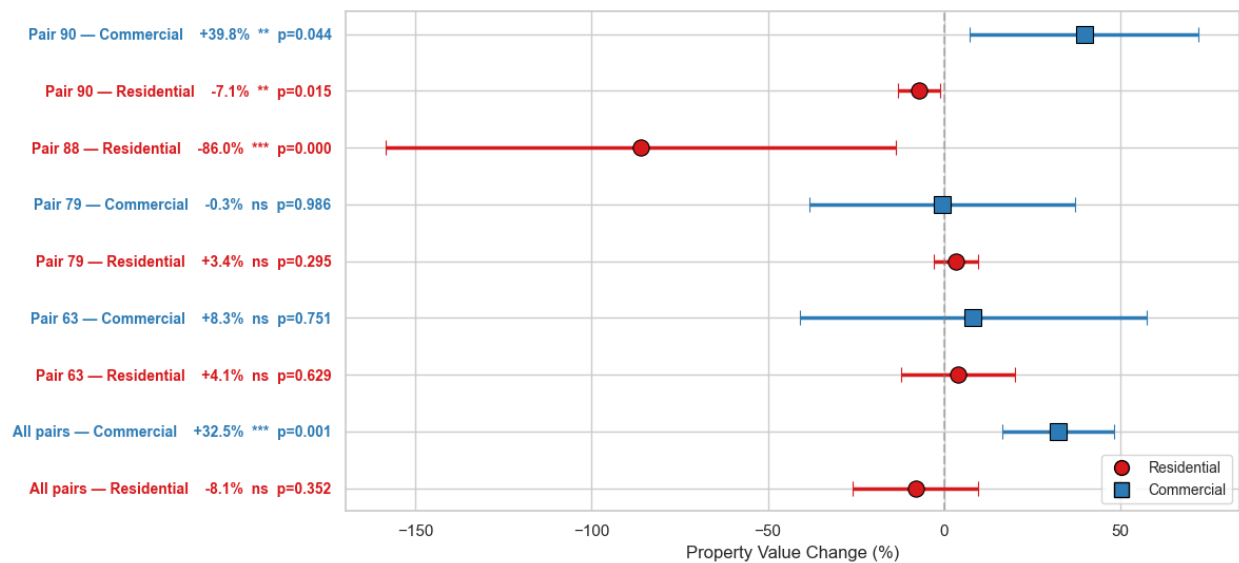


Figure 6: Plot. Pair level DiD for residential property value (red circles) and commercial (blue squares) parcels, pooled and by pair. Whiskers are 95% CI.

Secondary RCUT pairs

The four supporting pairs were analyzed using adjacent parcels with a simpler pre/post comparison of log valuation changes (t test of treatment vs control per parcel change). Sample sizes ranged from five to seven parcels per treatment and control group, which is a small sample. All four estimates were not significant at conventional levels. Point estimates ranged from

negative 27.5% (RCUT 53) to positive 32.4% (RCUT 14). No directional pattern held across the four pairs.

Table 7: Secondary property value DiD results for adjacent RCUT parcels.

Pair	Treat Δ	Ctrl Δ	DiD %	p value	Sig
RCUT 14	+10.5%	-16.5%	+32.42%	0.431	Not significant
RCUT 53	-26.0%	+2.1%	-27.51%	0.307	Not significant
RCUT 71	+28.0%	+62.1%	-21.00%	0.225	Not significant
RCUT 93	+15.4%	+2.6%	+12.43%	0.496	Not significant

Interpretation

The primary sample does not support a systematic negative property value effect from the RCUT installation at the corridor level. The pooled estimate is within sampling noise of zero and three of four individual pairs are not significant. Where negative effects do appear, they are concentrated within residential parcels on the minor road approach. Pair 88's residential / light-industrial sub effect is large and statistically robust, and the Warner Robins residential effect is modest but very precisely estimated. The mirror image appears on commercial parcels at Pair 90 and in the pooled commercial result which is consistent with commercial frontage on the main road benefiting from improved through flow under RCUT operation while residential parcels that lose direct left turn access lose value. The secondary sample is too small to either confirm or refute the primary pattern which signifies that future data collection must collect data up to 0.5-mile corridor for a comprehensive economic analysis. A post analysis geocoding and zoning alignment was conducted for all pairs. Processing facilities, truck yards, and small industrial parcels sit along the corridor. Pair 88's sub effect reported in **Table 11**. The direction and

magnitude of the DiD estimate do not change; the interpretive framing does. This matters for the screening framework as Alto RCUT imposed access friction on a corridor whose actual land use mix was more dependent on direct main road access than the tax class labels alone would suggest.

Buffer sensitivity

The primary DiD report above uses a 0.5 mi (approximately 2640ft) buffer. The VIIRS analysis uses 0, 330, and 1640ft circular buffer. That buffer asymmetry means the cross-method comparison averages over different economic footprints. A buffer sensitivity check was added that re estimates the property DiD at 330, 1640, and 2640ft for every pair where per parcel coordinates are available.

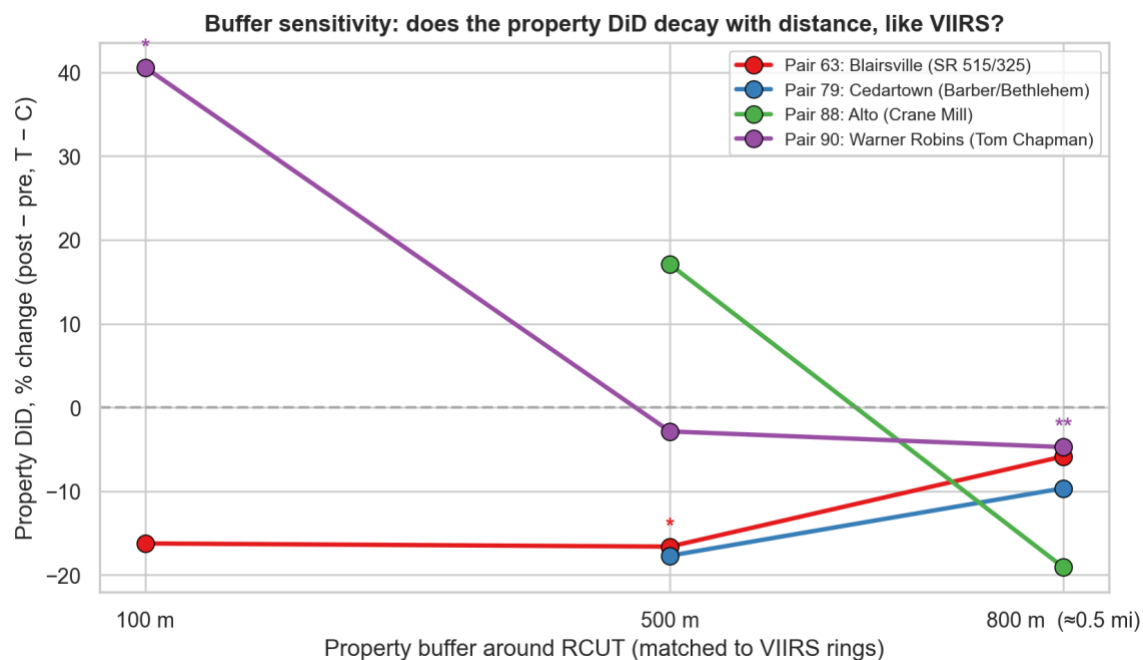


Figure 8: Plot. Property DiD across three matched buffers.

Three things come out of this sensitivity pass. First, RCUT Pair 79 is the only pair with both treatment and control coordinates at both 1640ft and 2640ft, so it is the only pair where a like for

like property and VIIRS comparison can be run at 1640ft (see Section 6.3.5). Second, Pair 88 flips sign from negative at 2640ft (-19%) to positive at 1640ft (+17%) on a smaller subsample. Neither point estimate is significant, but the flip indicates the negative signal at Alto is carried by parcels that sit beyond 1640ft from the intersection, in the outer part of the 0.5 mi buffer. That is consistent with a corridor level access effect rather than a micro local intersection node effect at this pair.

Table 13: Coordinate-Matched Buffer Sensitivity Results for Property Value DiD (Site Pair and Buffer Radius)

Pair	Buffer	n parcels	DiD %	p value	Sig	Notes
63	330ft	6	-16.2%	0.414	Not significant	very thin coord sample
63	1640ft	57	-16.6%	0.078	*	
63	2640ft	106	-5.8%	0.360	Not significant	
79	1640ft	73	-17.7%	0.245	Not significant	treat and control coords both present
79	2640ft	117	-9.7%	0.389	Not significant	
88	1640ft	97	+17.1%	0.248	Not significant	sign flip vs headline 0.5 mi
88	2640ft	237	-19.1%	0.140	Not significant	closer to headline direction
90	330ft	18	+40.6%	0.071	*	small n but suggestive
90	1640ft	273	-2.9%	0.427	Not significant	
90	2640ft m	742	-4.7%	0.016	**	matches original headline direction

*Primary property value DiD. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*

6.2 REMOTE SENSING (VIIRS NIGHTTIME LIGHTS) ANALYSIS

Primary results

The Monthly Interrupted Time Series (MITS) coefficients, p values, and parallel trends test results for each RCUT and control pair across 0, 330, and 1640ft buffers are seen in Table 14. Pair 63 produced small positive coefficients that were statistically significant across all 3 buffers. However, interpretation is limited as the 330ft buffer fails the formal parallel trends test (pre trend $p = 0.075$), indicating weaker identifications. Pair 79 is effectively null at the 0 and 330ft buffers and only marginally negative at the 1640ft buffer ($p = 0.080$), suggesting little evidence of a measurable post RCUT change in nighttime activity. Pair 88, shows consistent negative post

period effects, with coefficients of -0.469, -0.443, and -0.173 at the 0ft, 330ft, and 1640ft buffers, respectively. At Pair 88, the de-seasonalized trend remains consistency below the control group after installation, reinforcing the negative post-period coefficients observed in Table 14 and **Figure 11**. This pattern is also visible in **Figure 10** and **Figure 13**, where treatment site radiance remains below the control group after installation and the treatment minus control heatmap shows persistent negative differences closest to the RCUT. In contrast, Pair 90 shows a positive post period response, with coefficients of +0.546, +0.488, and +0.372 across all three buffers. Although the effect weakens with distance, all three estimates remain statistically significant, suggesting increased nighttime economic activity near RCUT following installations. **Figure 10** and **Figure 12**, which support this interpretation by showing sustained post installation increase in treatment site radiance relative to the control group, particularly in the 0 and 330ft buffers.

Table 14: VIIRS MITS results by pair and buffer

Pair	Buffer	MITS coefficient	MITS p value	Pre trend p value	Parallel?	Sig
Blairsville (63)	0ft	+0.063	0.008	0.244	OK	***
Blairsville (63)	330ft	+0.058	0.002	0.075	VIOLATED	***
Blairsville (63)	1640ft	+0.039	0.007	0.185	OK	***
Cedartown (79)	0ft	-0.036	0.576	0.714	OK	Not significant
Cedartown (79)	330ft	-0.055	0.333	0.975	OK	Not significant
Cedartown (79)	1640ft	-0.077	0.080	0.603	OK	*
Alto (88)	0ft	-0.469	0.003	0.130	OK	***
Alto (88)	330ft	-0.443	0.004	0.116	OK	***
Alto (88)	1640ft	-0.173	0.068	0.342	OK	*
Warner Robins (90)	0ft	+0.546	0.044	0.276	OK	**
Warner Robins (90)	330ft	+0.488	0.062	0.232	OK	*
Warner Robins (90)	1640ft	+0.372	0.081	0.147	OK	*

*Sig: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*

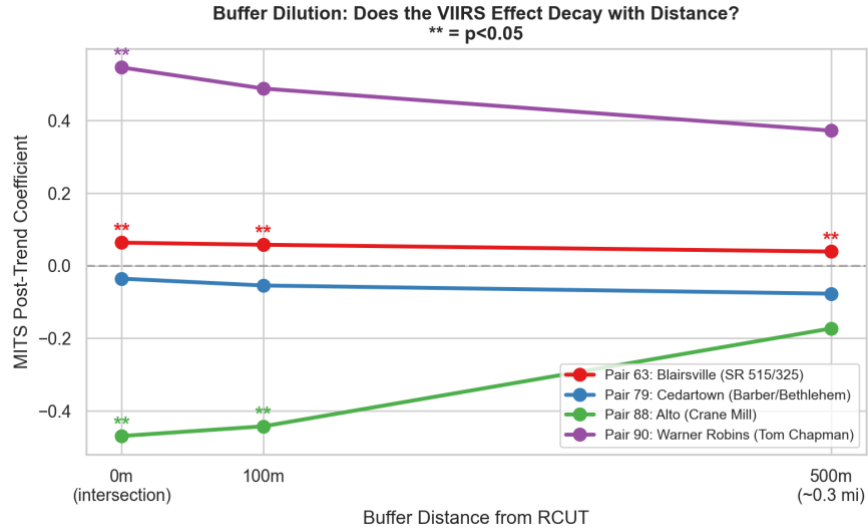


Figure 9: Plot. Buffer dilution of the MITS coefficient.

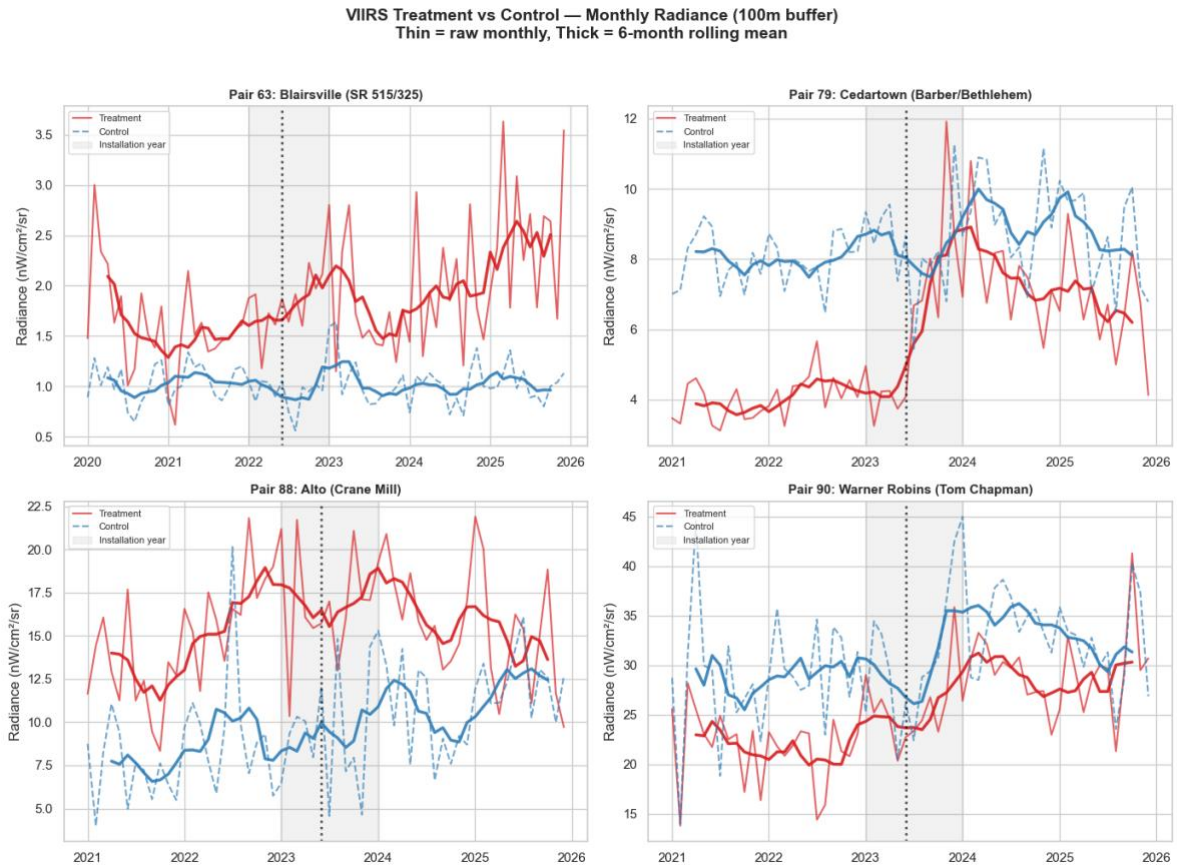


Figure 10: Plots. Treatment and control monthly radiance time series per pair (330ft buffer), with the installation year located in the middle marked by a gray border.

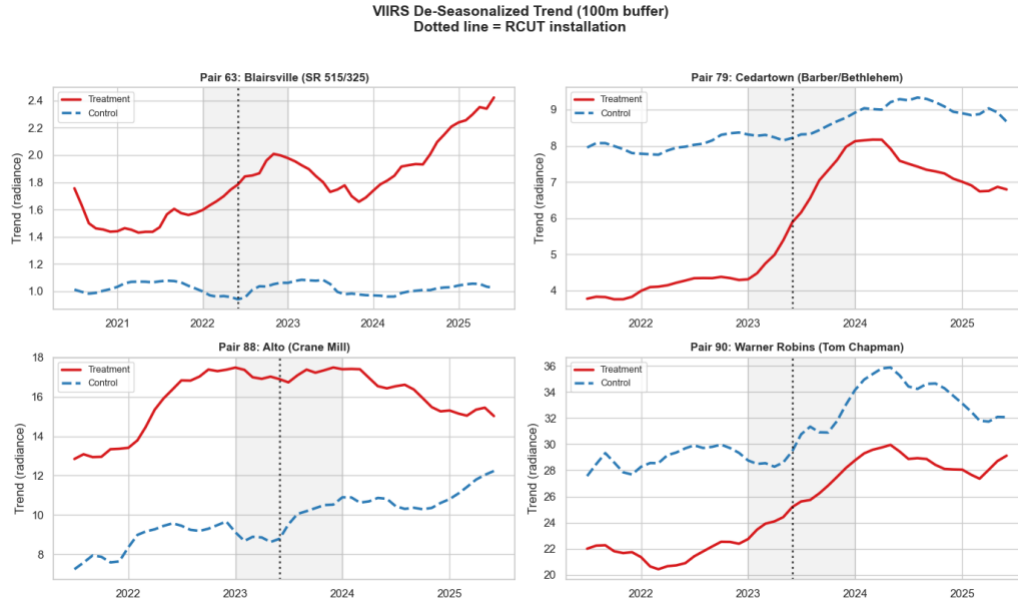


Figure 11: Plots. Seasonal decomposition.

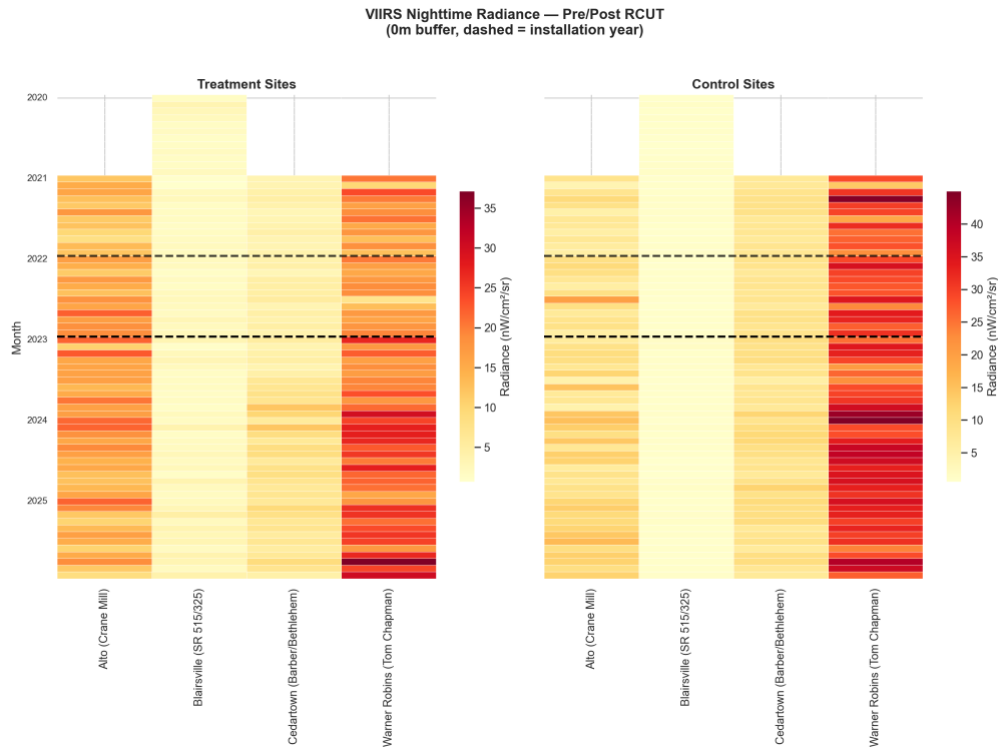


Figure 12: Plots. Monthly radiance heatmap for treatment and control sites, primary pairs. Rows are months, columns are pairs. The dashed horizontal line marks each pair's installation month.

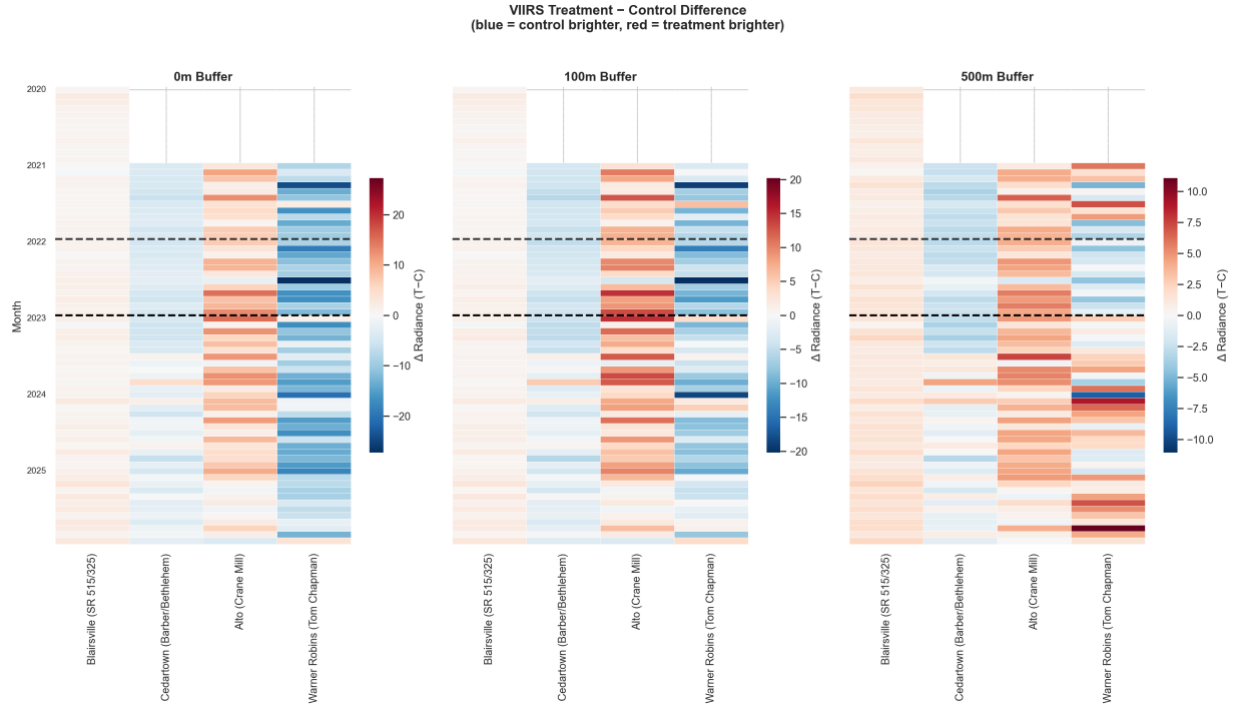


Figure 13: Plots. Treatment minus control radiance heatmap at 0ft, 330ft, and 1640ft buffers. Blue cells are treatment below control, red cells are above.

Cross method agreement

The property value DiD and VIIRS MITS results can be compared pair by pair using

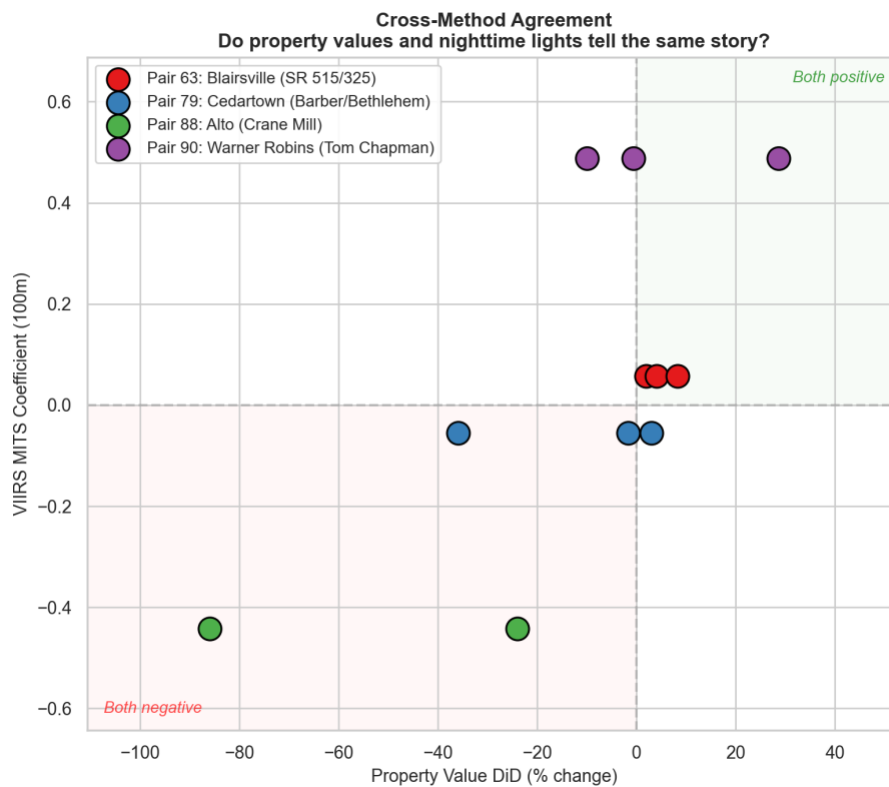


Figure 14 and Figure 15. **Figure 15** aligns annual property value trends with VIIRS nighttime radiance changes for each primary RCUT pair and shows whether both methods move in the same direction over time. Only one pair, Pair 88, shows both methods moving in the same direction with statistical significance, with declining property values and negative VIIRS post-period effects indicating localized economic decline following RCUT installation. This consistency makes Pair 88 the strongest cross-method finding in the study. Pair 90 shows flat pooled property values overall but a large commercial gain and a positive VIIRS signal, which is consistent with commercial activity increasing without a large shift in total parcel values. **Figure 15** shows rising nighttime radiance after installation even while overall assessed property values remain relatively stable, supporting the interpretation that economic activity may have increased

without broad appreciation across all parcel types. Pair 63 shows a positive VIIRS signal but the 330ft parallel trends violation weakens confidence in that result, while property values remain statistically insignificant. Pair 79 is largely flat across both methods, showing little evidence of measurable post-RCUT change. The cross-method scatter in

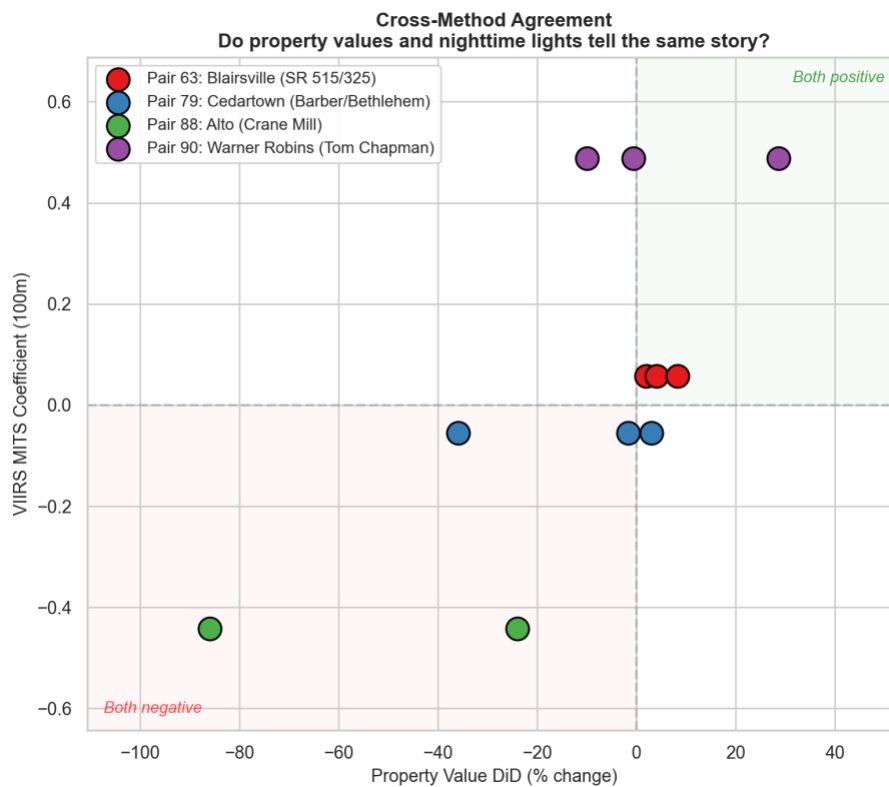


Figure 14 places Pair 88 deep in the negative quadrant, while Pair 79 also falls in that quadrant but remains close to the origin, indicating only weak effects. Pairs 63 and 90 fall on the positive VIIRS side, reflecting stronger nighttime light responses than property value changes. Pearson correlations between annual mean assessed property values and annual mean VIIRS radiance at the 330ft buffer range from $r = -0.44$ to $r = +0.57$ and are mixed in direction; none reach statistical significance at the pair level.

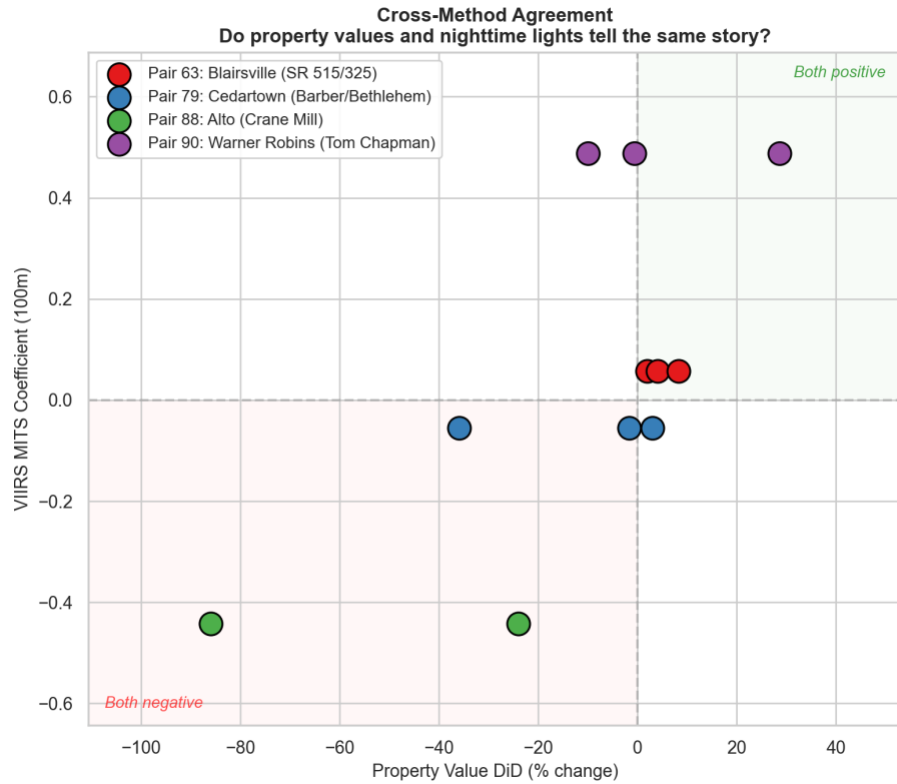


Figure 14: Plot. Cross method scatter. Horizontal axis: pair level property DiD (%). Vertical axis: VIIRS MITS coefficient at 330ft.

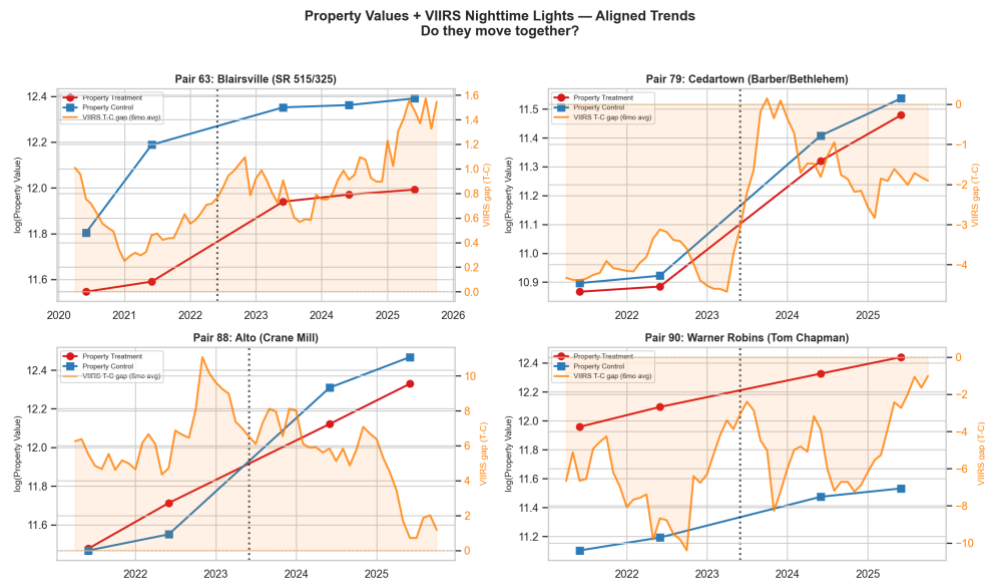


Figure 15: Plots. Aligned trend lines: annual treatment minus control property value gap (blue) and VIIRS treatment minus control radiance gap (orange).

Interpretation

The VIIRS data analysis reinforces two conclusions from the property value analysis. The first conclusion is the strongest and only mutually confirmed negative economic signal is at Pair 88. The second conclusion is the Pair 90's signal is consistent with commercial gain even when the pooled property estimate is flat. The buffer dilution pattern is particularly important for causal interpretation. If a VIIRS signal were driven by a corridor wide economic trend or impact, we would not expect the effect to shrink between 0ft and 1640ft. Three of four pairs (63, 88, 90) show the MITS coefficient shrinking as the buffer increases, which is consistent with the intersection itself being the source of the signal.

Matched buffer cross method read at 1640ft

A matched-buffer cross-method comparison was added at 1640ft (approximately 0.31 miles) to place both the property value DiD estimates and the VIIRS MITS coefficients on the same spatial scale. **Table 14** summarizes the matched 1640ft estimates for each pair, while **Figure 16** and **Figure 17** visualize the directional agreement and coefficient differences between methods. The purpose of this comparison is to separate genuine cross-method disagreement from simple buffer asymmetry. In the primary analysis, the two methods operate at different spatial scales: property values reflect a broader economic catchment, while VIIRS captures radiance concentrated near the RCUT intersection node. The 1640ft matched-buffer diagnostic helps determine whether disagreement between methods is substantive or simply a result of scale differences. **Figure 16** plots property value DiD against VIIRS MITS coefficients at the shared 1640ft buffer, while **Figure 17** compares the matched coefficients directly by pair. Three important patterns emerge. First, Pair 79 is the only pair where both methods fall in the same quadrant, with both property values and VIIRS showing negative effects at 1640ft. This

represents the cleanest cross-method corroboration at a shared spatial scale and suggests a null to modestly negative economic effect rather than strong economic disruption. Second, Pair 88 reverses direction. At the headline study scale, Pair 88 is the strongest negative finding in the study, with significant declines in both nearby property values and VIIRS nighttime radiance. However, at the matched 1640ft buffer, property values shift to a positive but insignificant estimate of +17%, while VIIRS remains negative at -0.173. This suggests that the strongest property value decline at Pair 88 is carried by parcels farther from the immediate intersection, likely within the broader 500 to 800ft corridor, while the VIIRS decline reflects activity concentrated directly at the intersection node. This supports the light industrial zoning interpretation and suggests that radiance loss may reflect operational or construction changes at the poultry facility rather than a broad land value decline. Third, Pairs 63 and 90 show agreement in the headline analyses but disagreement in the matched 1640ft comparison. Pair 63 shows declining property values but a positive VIIRS signal, while Pair 90 shows relatively flat overall property values and positive VIIRS growth. These mixed results suggest that neither site has a fully stable internal story, and both would benefit from longer post-treatment periods before strong policy conclusions are drawn. The matched 1640ft comparison should be interpreted as a diagnostic rather than a replacement for the primary results. The strongest overall cross-method agreement in the study remains Pair 88 at the headline study scales, while Pair 79 provides the cleanest agreement under strict matched-buffer comparison.

Table 15: Matched-Buffer Cross-Method Comparison of Property Value DiD and VIIRS MITS Results (1640ft)

Pair	Property DiD % at 1640ft	Property p	Property sig	VIIRS MITS at 1640ft	VIIRS p	VIIRS sig	Direction agreement
63 Blairsville	-16.6%	0.078	*	+0.039	0.007	***	Disagree: property down, VIIRS up
79 Cedartown	-17.7%	0.245	ns	-0.077	0.080	*	Agree: both negative

88 Alto	+17.1%	0.248	ns	-0.173	0.068	*	Disagree: property up, VIIRS down
90 Warner Robins	-2.9%	0.427	ns	+0.372	0.081	*	Disagree: property flat, VIIRS up

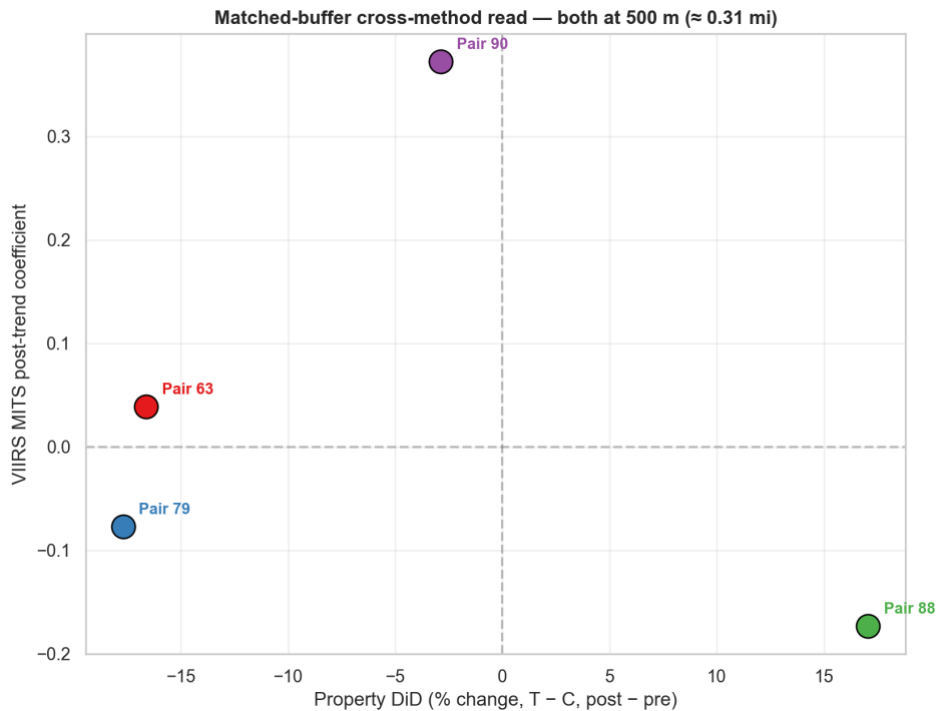


Figure 16: Plot. Cross-Method Scatter Plot at 1640ft Buffer. Property Value DiD (X) vs VIIRS MITS (Y).

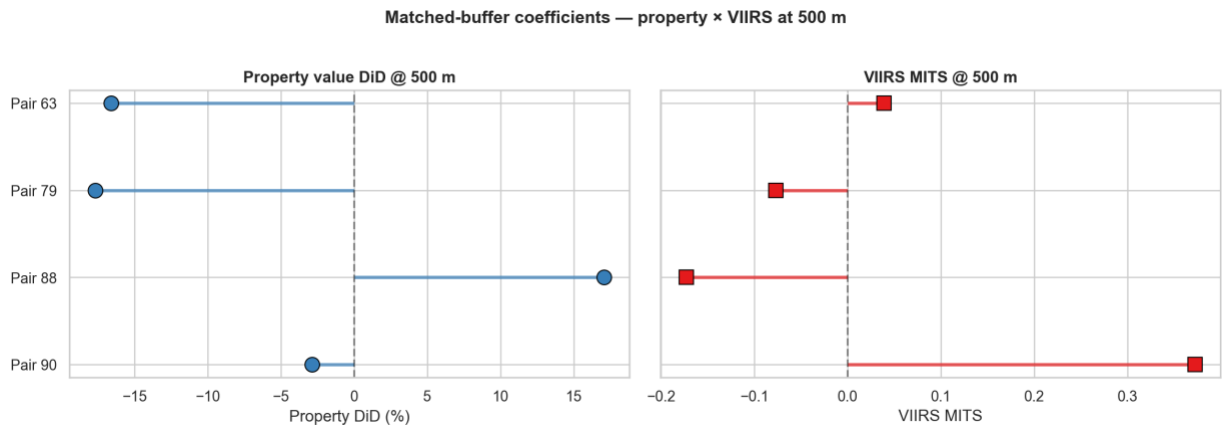


Figure 17: Plots. Matched-Buffer Coefficient at 1640ft. Property Value (Left) and VIIRS MITS (Right) by Pair.

6.3 ACCESSIBILITY RESULTS

Decay Model Applied to Primary Study Pairs

The decay model was applied to the four primary study pairs (63, 79, 88, 90) using field-measured deviation distances for both the southbound-to-northbound (S-N) and northbound-to-southbound (N-S) approach directions. **Table 16** reports the deviation distance, baseline probability, post-RCUT n_i , percent loss relative to the pre RCUT baseline, and the directional asymmetry for each pair.

Table 16: Decay model results for the four primary study pairs by direction of approach

Pair	Direction	d_i mi	p	n_i Post	% Loss	Asym (pts)
63	S-N	0.48	0.1	0.043	-56.8%	4.7
	N-S	0.71	0.1	0.038	-61.5%	
79	S-N	0.64	0.1	0.040	-60.1%	0.6
	N-S	0.61	0.1	0.040	-59.5%	
88	S-N	1.68	0.1	0.024	-76.3%	11.0
	N-S	0.92	0.1	0.035	-65.4%	
90	S-N	0.63	0.1	0.040	-59.9%	8.4
	N-S	0.25	0.1	0.048	-51.6%	

Constants: $k_d = 0.50$, $k_t = 0.30$, $t_i = 2$

Pair 88 shows the largest accessibility loss in both directions: 76.3% for S-N approaches ($d_i = 1.68$ miles) and 65.4% for N-S ($d_i = 0.92$ miles). These are the largest deviation distances in the sample, reflecting the absence of a dedicated U-turn crossover and the reliance on a downstream intersection 1.68 miles away in the S-N direction. Pair 63, shows losses of 56.8% and 61.5% for the two directions. Pairs 79, and 90, cluster near 59-60% loss in the longer-detour directions. The smallest loss in the sample is Pair 90 N-S at 51.6%, where $d_i = 0.25$ miles, the shortest detour distance among all measured approach directions.

Directional Asymmetry and Quadrant Effects

A notable feature of the deviation distance measurements is that d_i differs by direction of approach at most sites because U-turn opportunities are not placed equidistant in both directions from the RCUT. This creates a directional asymmetry in n_i that maps directly to unequal accessibility impacts across the four business quadrants surrounding an intersection. Businesses in the quadrant approached from the longer-detour direction face a measurably higher loss than their diagonal counterparts. **Table 17** summarizes the directional losses and cross-references the empirical economic outcomes from the property value DiD and VIIRS MITS analyses.

Table 17: Accessibility loss comparison across primary study pairs, with cross-reference to property value DiD and VIIRS MITS outcomes

Pair	S→N Loss	N→S Loss	Avg Loss	Asym	DiD / VIIRS Outcome
63	-56.8%	-61.5%	-59.2%	4.7 pts	Moderate (VIIRS sig, parallel trends caution)
79	-60.1%	-59.5%	-59.8%	0.6 pts	Negligible (both null)
88	-76.3%	-65.4%	-70.8%	11.0 pts	Significant (both negative, $p < 0.05$)
90	-59.9%	-51.6%	-55.8%	8.4 pts	Significant (distributional: residential -10%, commercial +29%)

Average loss -39.5% (pre-RCUT $n = 0.200 \rightarrow$ post-RCUT $n = 0.121$, $p = 0.20$); directional asymmetry 20.4 percentage points, the largest in the sample. Pair 88 (11.0 pts) becomes the second-largest. Pair 63 shows 4.7 pp. Pair 79 is nearly symmetric at 0.6 pp, consistent with balanced median opening spacing in both directions. The cross-reference in **Table 17** shows that the significant classification aligns with the highest accessibility losses Pair 88 (average 70.8% loss, both empirical methods agree on a negative effect) and Pair 90 (average 55.8% loss, distributional impact with residential loss and commercial gain).

U-turn crossover Proximity

The model was used to evaluate a hypothetical design alternative in which a dedicated U-turn crossover is placed 0.20 miles from the minor road stop bar, which is close enough to be visible from the intersection. The decay model captures the share of would-be impulsive customers (those who would have entered the business spontaneously under the pre-RCUT geometry), who are retained as a detour distance increases. It does not describe the loss of destination-driven customers, who are largely unaffected by detour length.

Under this scenario:

$$n_i = 0.10 \times e^{(-0.50 \times 0.20 - 0.30 \times 2)} = 0.10 \times 0.497 = 0.050$$

Compared to the current range of 51.6% to 76.3% loss across the sample, a bay at 0.20 miles sets a loss of 50.3% at every site. The recovery defined as the reduction in percent loss when d_i is shortened to 0.20 miles, which varies substantially by current detour distance. This can be seen in **Table 18**:

Table 18: Recovery in accessibility loss if a U-turn crossover were placed at 0.20 miles from the intersection, sorted by recovery magnitude.

Pair	Direction	Current d_i	Current Loss	At $d_i = 0.20\text{mi}$	Recovery
88	S-N	1.68 mi	-76.3%	-50.3%	+26.0 pp
	N-S	0.92 mi	-65.4%	-50.3%	+15.0 pp
63	N-S	0.71 mi	-61.5%	-50.3%	+11.2 pp
	S-N	0.64 mi	-60.1%	-50.3%	+9.8 pp
79	N-S	0.61 mi	-59.5%	-50.3%	+9.2 pp
	S-N	0.63 mi	-59.9%	-50.3%	+9.6 pp
90	S-N	0.48 mi	-56.8%	-50.3%	+6.5 pp
	N-S	0.25 mi	-51.6%	-50.3%	+1.2 pp

The largest recovery occurs at Alto S-N (+26.0 pp), where the current detour of 1.68 miles is nearly 9 times the hypothetical 0.20-mile bay distance. For Pair 90 N-S, which already has the shortest detour at 0.25 miles, the recovery is minimal (+1.2 pp), as the current configuration is already near the 0.20-mile scenario. The recovery pattern demonstrates that moving the bay from 1.68 to 0.20 miles recovers 26 points, but moving from 0.25 to 0.20 miles recovers only 1.2 points. The steepest gains occur when the current detour exceeds 0.60mi. This result motivates Enhancement Rule 1 (U-turn crossover placement) in the screening guideline: prioritize bay proximity at sites where the current nearest U-turn opportunity is more than 0.5 miles from the intersection.

Interpretation

Three findings connect the decay model to the broader evidence in this chapter. First, all accessibility loss is concentrated in the minor-road cross, left-turn, and U-turn movements. The 10 major-road movements that generate the majority of route AADT are unaffected by the RCUT. The pass-by movements that deliver 85-95% of total customer volume retains full direct access. Second, the directional asymmetry finding is directly supported by the field-measured d_i values: the direction with the longer detour consistently imposes a larger n_i loss. At Pair 88, the difference exceeds 11 pp within the same intersection. At Pair 90, the difference is 8.4 pp. This asymmetry maps directly to unequal impacts across business quadrants. Third, the cross-method alignment at Pair 88 which had the highest n_i losses, the largest negative property value DiD (-24%, $p = 0.013$), and the largest negative VIIRS MITS coefficient (-0.443, $p = 0.004$) in the sample, provides evidence that the decay model captures a real accessibility cost rather than a modeling artifact. Conversely, Pair 79's null economic outcome despite a 59.8% average predicted loss demonstrates that the model is a worst case upper bound. It quantifies the

maximum geometric penalty from the minor road but does not account for compensatory access features that can offset that penalty in practice.

6.4 SURVEY RESULTS

Business findings

Respondent profile

While the primary focus of this study is the quantitative analysis of economic impacts using parcel-level tax assessment data and VIIRS nighttime lights, the survey component serves as a secondary source of evidence to provide additional information on how businesses perceive RCUT-related changes.

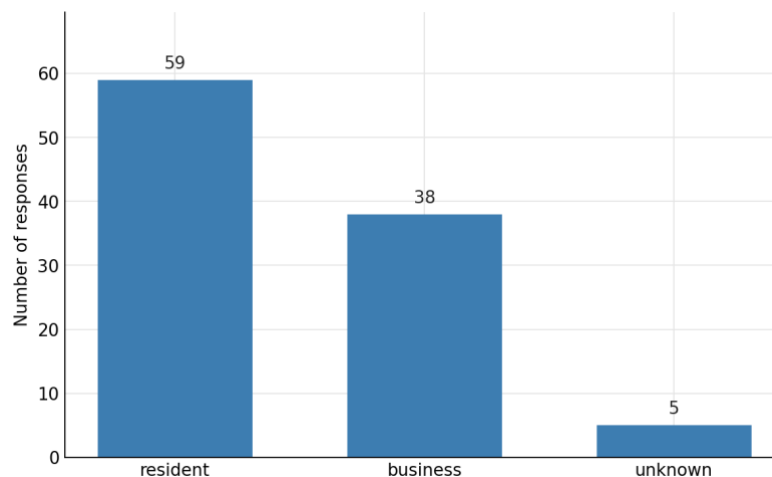


Figure 18: Plot. Distribution of survey responses by respondent type

Survey respondent composition across the three sites, as seen in **Figure 18** Resident and patron respondents (59) outnumber business respondents (38) by roughly 3 to 2, reflecting the practical reality that residents and patrons outnumber business owners and employees on any given commercial corridor. The business sample is smaller but includes the people who carry the most

direct economic exposure to the RCUT. Business respondents by frequency of travel through the area. As seen in **Figure 19**, 21 of 38 reported daily presence, indicating a sample weighted toward respondents with regular exposure to the corridor. A daily heavy sample is what is wanted for revenue and volume questions, since transient observers cannot speak to changes that are visible only across many trips.

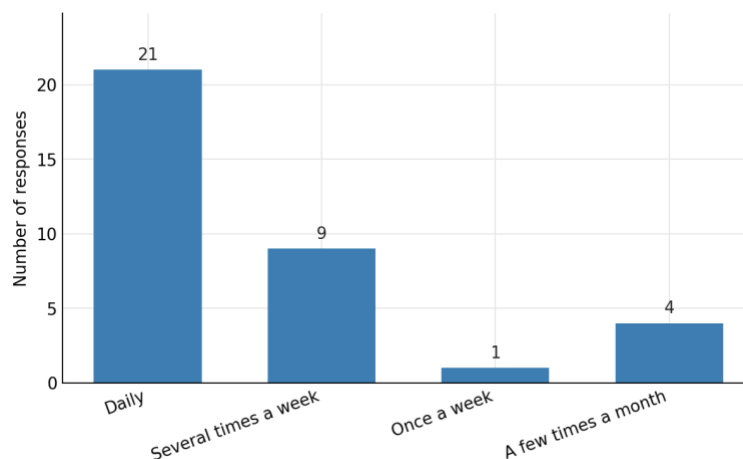


Figure 19: Plot. Frequency of visits reported by survey respondents, showing the number of respondents who use the corridor daily, several times a week, once a week, or a few times a month

Most surveyed businesses reported moderate to high customer volumes, as seen in **Figure 20**, share largest share, 9 responses reported more than 100 customers per day, followed by 7 respondents reporting 51-100 customers daily, 5 respondents reporting 25-50 customers, and only 3 reported fewer than 25 customers per day. This suggests that the sample primarily reflects established businesses with consistent customer activity, making perceptions of access and traffic flow particularly relevant.

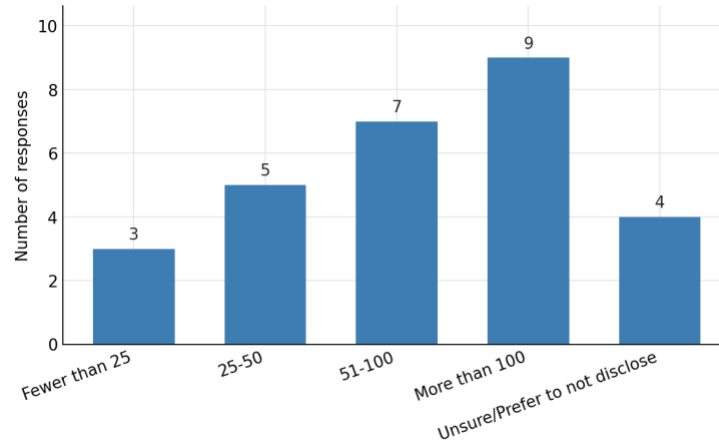


Figure 20: Plot. Daily customer volume reported by surveyed businesses

As seen in **Figure 21**, primary commute mode for employees of the surveyed businesses.

Driving alone dominates the response set (22 of 38), with carpool and other modes a minority.

RCUT detours fall on every employee who arrives by car, since none of these respondents have a transit alternative that would route around the converted intersection.

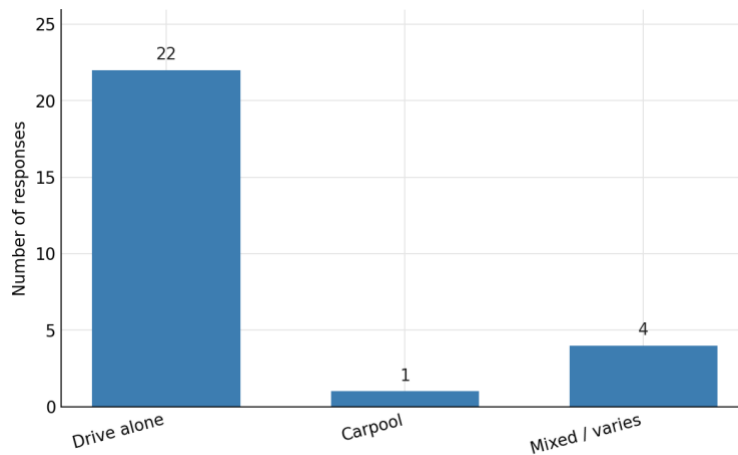


Figure 21: Plot. Primary travel mode reported by Business Respondents

Revenue and customer volume

Revenue change over the past year was flat or positive for the substantive business respondents, as seen in **Figure 22**, of the 12 business owners who gave a quantitative answer, 5 reported an increase and 1 reported a decrease.

Majority of business owners and employees either did not want to report revenue information or did they did not know the revenue information of the business.

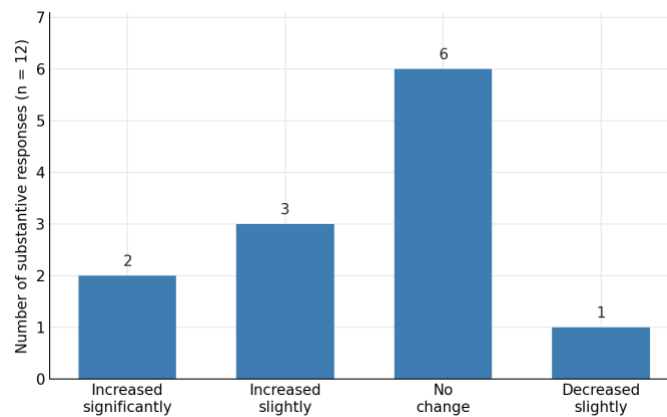


Figure 22: Plot. Business reported revenue change in the past year

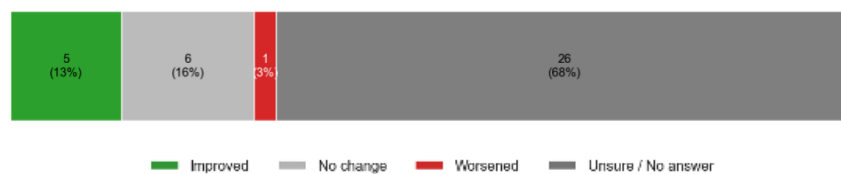


Figure 23: Plot. Business reported revenue change in the past year, including unsure/no responses

Customer volume over the same, as seen in **Figure 24** were more clearly positive, with 12 of 23 substantive answers reported increased volume, 9 reported no change, and only 2 reported a decline. A business respondent who is uncertain about whether revenue rose can still report whether the parking lot was busier, which is part of why the volume question is more

informative at this sample size. As seen in **Figure 23**, the 32% response rate on the revenue item is main limitation on this finding, with nonresponses. The low substantive count means a single additional decline response would shift the headline percentages noticeably.

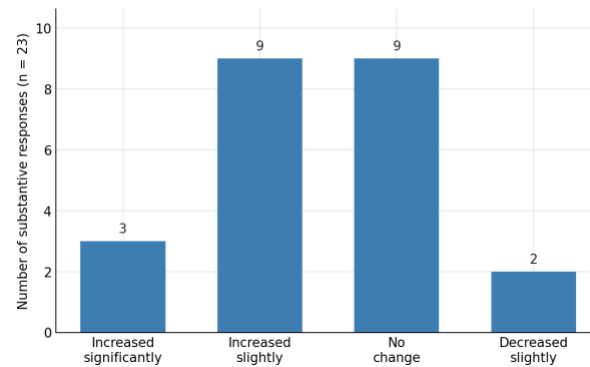


Figure 24: Plot. Business reported customer volume change in the past year, respondents who were unsure were not included in this figure

Figure 25 shows the relationship between perceived revenue change and customer volume change among surveyed businesses. Most responses were concentrated in the “improved,” and “no change” categories, with 4 businesses reporting both improved revenue and improved customer volume, and another 4-reporting no change in either measure. Only 1 business reported worsening revenue, and no respondents reported worsening customer volume. The positive Spearman correlation ($p = 0.64$) suggests a moderate association between customer volume and revenue perception, indicating that businesses experiencing high customer traffic were also more likely to report revenue improvements. The pattern is consistent with a corridor where customer volume holds steady or rises modestly without an accompanying revenue swing. However, the chi-square test was not statistically significant ($p = 0.103$), suggesting that this relationship should be interpreted cautiously given the small sample size.



Figure 25: Plot. Relationship between perceived revenue change and customer volume change among surveyed businesses. Cells on the diagonal indicate respondents whose revenue and volume perception track together.

Vehicle access and operational adjustments

This question is important because RCUT intersections often change how vehicles enter and exit commercial properties, which can directly affect daily business operations. Changes in turning movements, delivery access, customer convenience, and circulation patterns may influence whether businesses experience disruptions, delays, or the need to modify loading zones, signage, or internal traffic flow. Only 3 of 38 business respondents rated vehicle access for customers as somewhat or extremely difficult. None reported changing operating hours, 4 reported adjusting delivery or freight scheduling, 2 updated their online directions, and 1 changed staffing or hours. Customers rarely commented on access: only 6 of 27 substantive responses reported mostly negative comments, with 3 reporting mostly positive and 5 describing mixed feedback.

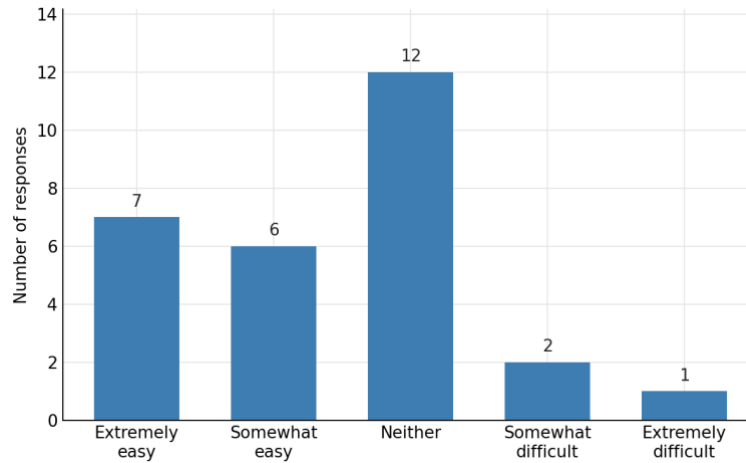


Figure 26: Plot. Business perception of vehicle access ease for customers

Congestion perception

This question is important because perceived congestion strongly influences how businesses evaluate RCUT performance, even when measurable economic impacts are limited. As seen in **Figure 27**, the most consistent business finding was perceived worsening of congestion, as 16 of 28 substantive respondents reported congestion had worsened (9 significantly, 7 slightly). Only 4 reported improvements. This is the reverse of the revenue direction. Businesses perceived that it has become harder to get to them, yet they are not reporting lost customers.

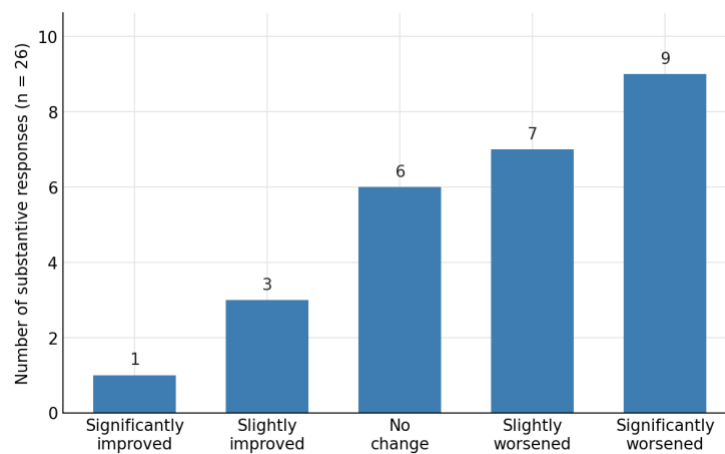


Figure 27: Plot. Business reported congestion change

The disconnect between perceived worsening congestion and stable to positive revenue is the most policy relevant finding in the business sample. It mirrors the perception gap documented in the comparable North Carolina DOT survey work, in which reported congestion frustration did not translate into a measurable revenue effect at commercial corridors.

Safety perception and crash observations

For safety perception, these questions are important because improved safety is one of the primary reasons RCUT intersections are implemented, particularly to reduce severe angle and left-turn crashes. Business owners' perceptions of safety, along with their observations of crashes or near-miss incidents, help evaluate whether these design benefits are visible at the local level. Business safety perception was roughly split, as 12 of 28 respondents reported feeling at least somewhat safe and 11 reported feeling somewhat or very unsafe. Crash or near miss observations were concentrated rather than universal: 4 of 26 substantive respondents reported frequent observations, 5 occasional, 6 rare, 6 never, and 5 unsure. Open ended comments referenced the Alto corridor geometry and driver behavior at the high-speed approaches more often than any other single concern.

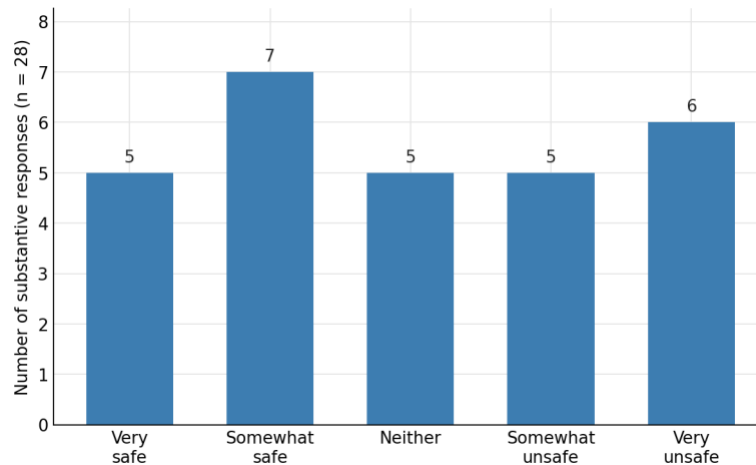


Figure 28: Plot. Business perceived traffic safety near the establishment.

Open-ended business recommendations

The final question on the business respondents survey was an open-ended recommendation on engineering and planning improvements. As seen in **Figure 29**, the responses result in 5 mentions of crosswalks or pedestrian improvements and 4 mentions of signalization. The keyword-based theme coding is coarse, and a single response can match multiple themes, so the counts should be read as relative emphasis rather than precise tallies.

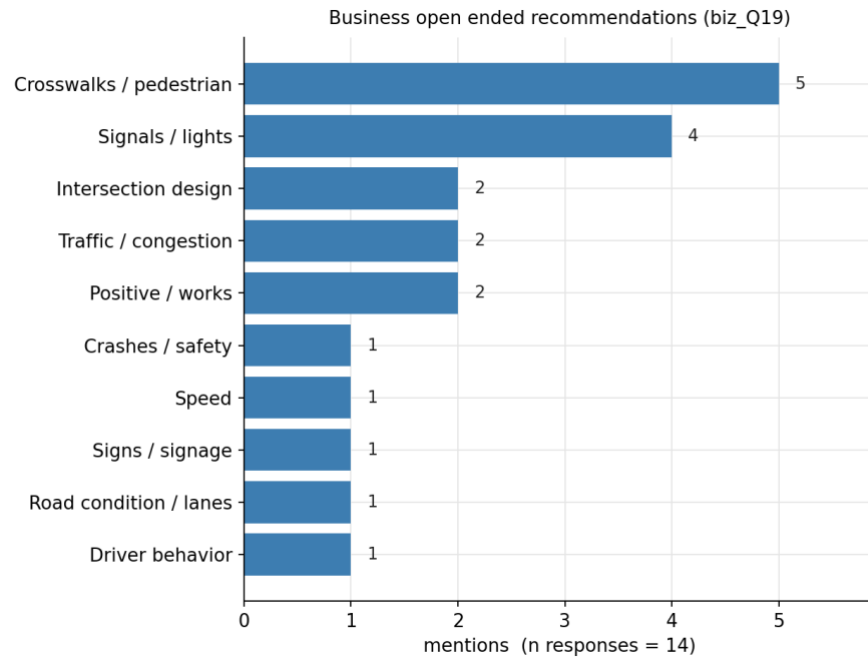


Figure 29: Plot. Theme coding of business open-ended recommendations

Cross tabulation test results

Twenty-five cross tabulations were tested across business and resident items. None reached $p < 0.05$ at the available sample size. With this many tests on samples in the 30 to 60 range, around 1 to 2 false positives at $p < 0.05$ are expected by chance alone, so even a single significant result would be suggestive rather than confirmatory at this sample size.

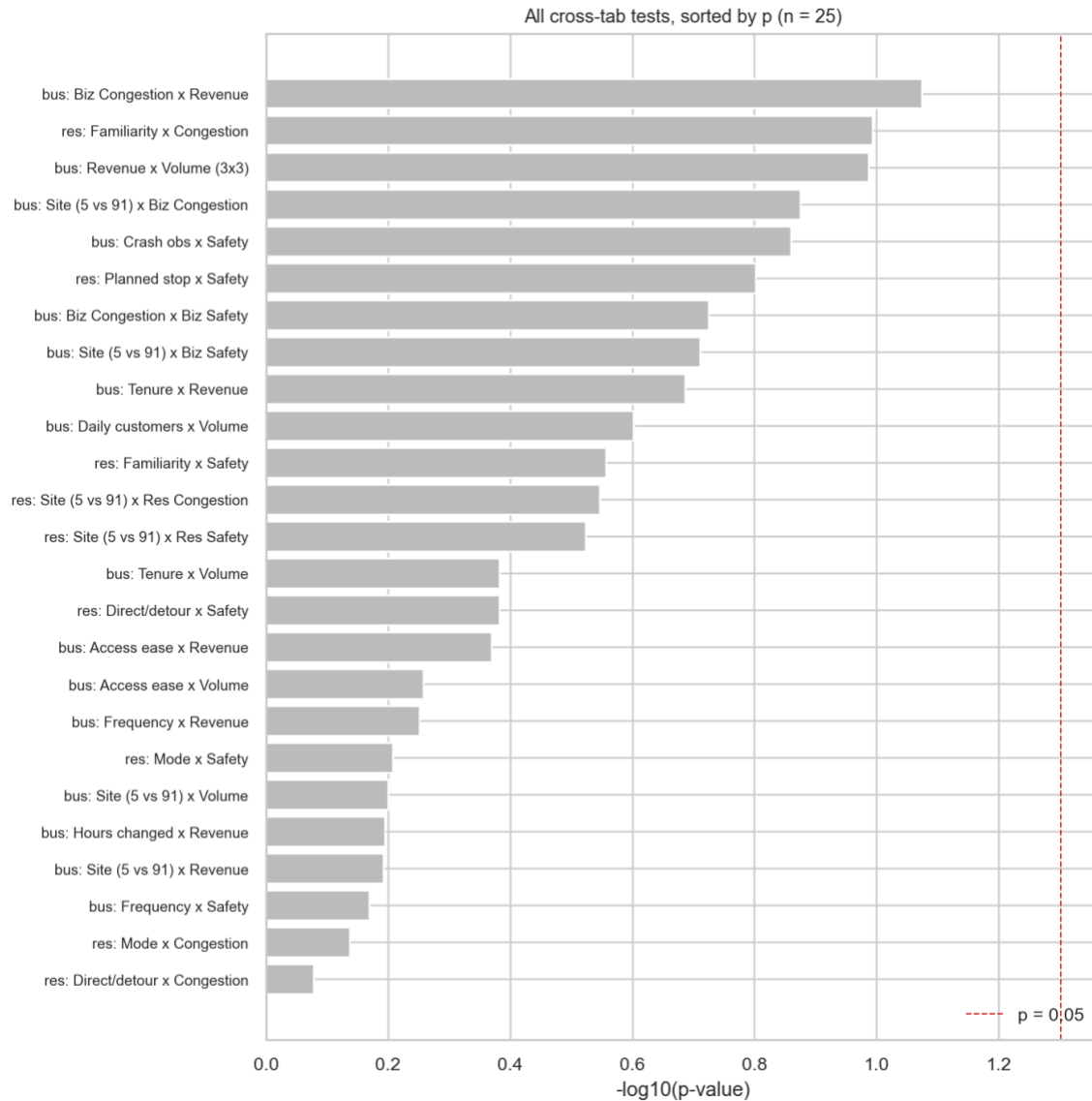


Figure 30: Plot. Summary of all cross-tabulation tests ranked by p-value

The survey does not detect strong dependencies between any single pair of items at this sample size. The pattern across items, particularly the perception gap between worsening congestion and stable revenue, carries more weight than any single test.

Wilson confidence intervals on headline percent estimates

Headline percent estimates are reported with Wilson 95 percent confidence intervals. As seen in **Table 19**, the intervals capture the uncertainty introduced by small substantive sample sizes, particularly on the revenue item where only 12 substantive responses are available.

Table 19: Wilson 95 percent confidence intervals for headline percent estimates

Item	k	n	%	low	high
Business: revenue improved	5	12	41.7%	19.3%	68.0%
Business: revenue worsened	1	12	8.3%	1.5%	35.4%
Business: volume improved	12	23	52.2%	33.0%	70.8%
Business: volume worsened	2	23	8.7%	2.4%	26.8%
Business: congestion worsened	16	26	61.5%	42.5%	77.6%
Resident: congestion worsened	19	42	45.2%	31.2%	60.1%
Business: feels unsafe	11	28	39.3%	23.6%	57.6%
Resident: feels unsafe	12	51	23.5%	14.0%	36.8%

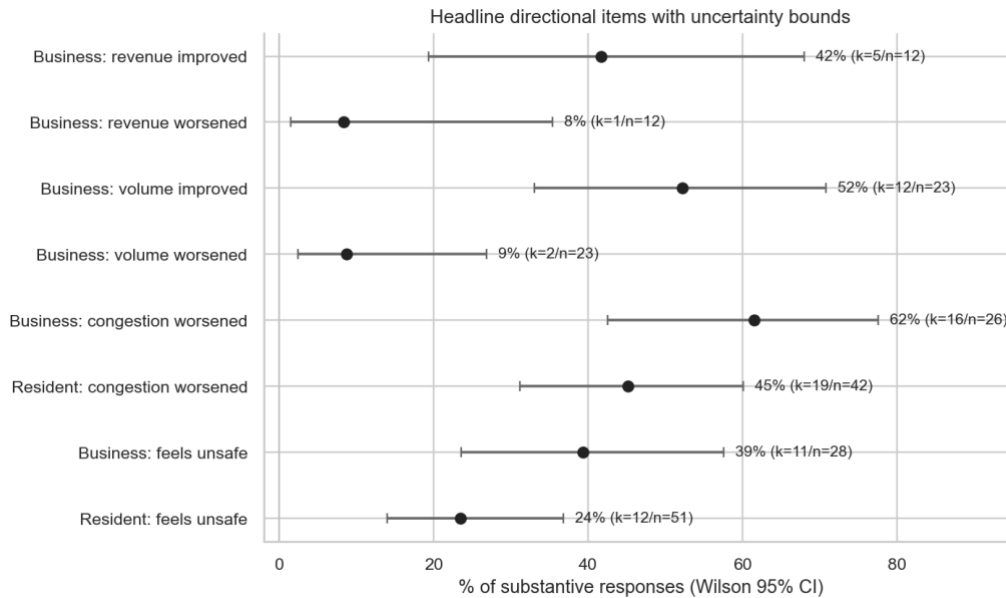


Figure 31: Plot. Wilson 95 percent confidence interval forest plot for the headline directional items

The intervals on the revenue items are wide, especially for revenue worsened, where the interval runs from 1.5% to 35.4%. That is a fair representation of what 1 of 12 substantive responses can support. The volume items, with twice the substantive sample, return tighter intervals.

Interpretation of the business sample

The business survey supports the conclusion in the property value and VIIRS chapters that RCUT conversion is not producing broad revenue harm at the sampled sites. The disconnect between worsened perceived congestion and stable to positive revenue is the policy relevant finding. It is consistent with the NCDOT RP 2020 47 result that perceptual opposition to RCUT conversion tends to exceed the measurable economic effect at commercial corridors. The finding is also consistent with the Texas DOT result that anticipated negative impacts exceed realized impacts and that businesses present through the full pre, during, and post period report better outcomes than businesses surveyed only before construction.

Resident and patron findings

Respondent profile

The resident branch of the survey collected 59 completed responses. The primary transportation mode was car for 49 of 59 (83%), with 2 respondents using another mode and 8 leaving the item blank. Area familiarity was high, 27 respondents reported being extremely familiar and 6 very familiar, which means more than half of the resident sample uses the corridor often enough to detect operational changes after RCUT conversion. Also, 49% used a combination of main road and side streets to access area businesses, 37% used the main road directly, and 59% of observed trips were planned stops while 23% were unplanned.

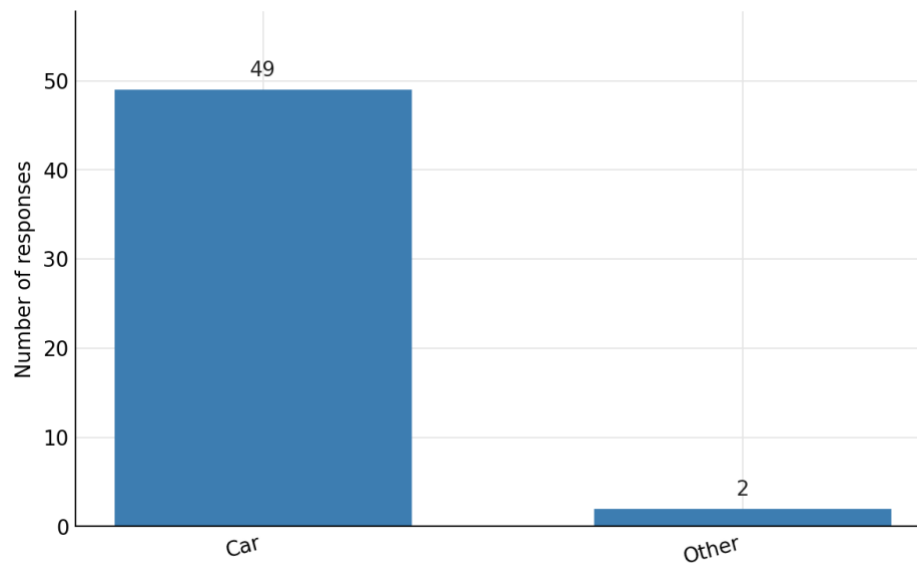


Figure 32: Plot. Primary mode of transportation reported by resident and patron respondents

Mode dominance by car means resident perceptions of the RCUT are filtered through the experience of driving the converted intersection rather than walking it. Pedestrian and bicycle perceptions are not represented in this sample and are flagged in the limitations.

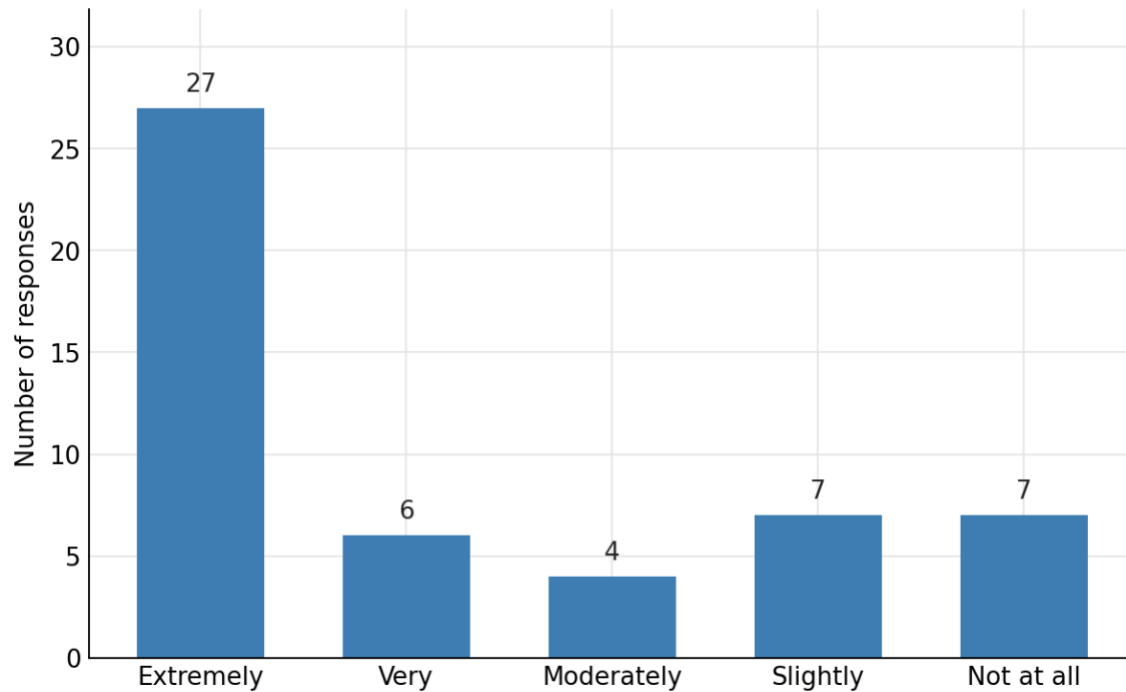


Figure 33: Plot. Resident familiarity with the area

A familiar sample is what the survey design called for. Respondents who use the corridor often enough to know what changed after construction are the only respondents whose perception comparisons are meaningful.

Congestion perception

Residents echoed the business worsening signal. Nineteen of 51 substantive residents reported congestion had worsened (10 significantly, 9 slightly) against 9 reporting improvement. The remaining 14 reported no change and 9 were unsure.

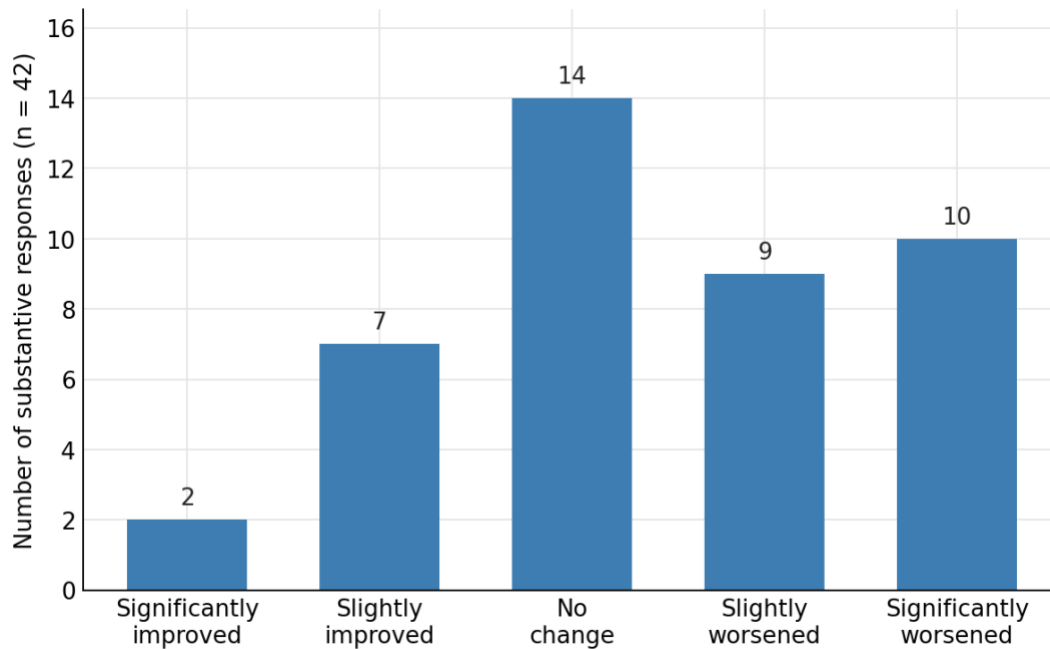


Figure 34: Plot. Resident reported congestion change

Residents and business directions agree on congestion. Both groups perceive that getting through the corridor has become harder since RCUT installation. This is the consistent perceptual signal across the survey, and it is also the perception that does not match the measured outcomes in the property value and VIIRS chapters.

Safety perception

Residents skewed positive on safety. Eighteen reported feeling very safe (31% of the resident sample) and 15 somewhat safe (25%). Twelve reported feeling somewhat or very unsafe. The resident distribution is more favorable than the business distribution, although a chi squared test of independence across the five response categories returns chi squared = 6.331, dof = 4, $p = 0.176$, meaning the two groups' distributions are not reliably different at this sample size.

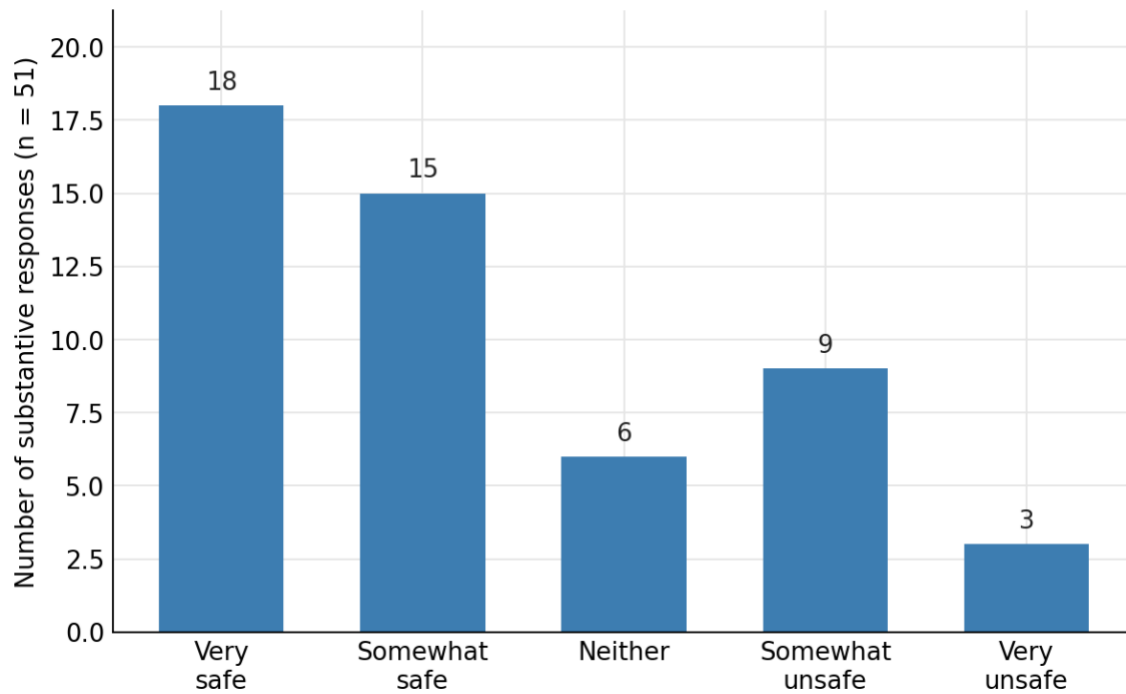


Figure 35: Plot. Resident perceived safety along the RCUT corridor

Resident safety perception is positive on net, which is consistent with the safety chapter finding of meaningful crash reductions at every treated pair where pre period injury counts were measurable. Residents are perceiving the same outcome the crash data shows, which is the strongest perception to measurement alignment in the survey.

Open ended themes

Resident open-ended responses on safety perception (n = 39) were thematically coded. Traffic or congestion was the most frequent theme (10 mentions), followed by crashes or safety (7), driver behavior (5), and positive comments (5). Speed was mentioned 4 times and signals 2 times. A second free text question on engineer or planner recommendations (n = 31) produced 10 mentions of traffic flow improvements, 6 of speed reductions, and 5 of additional signalization.

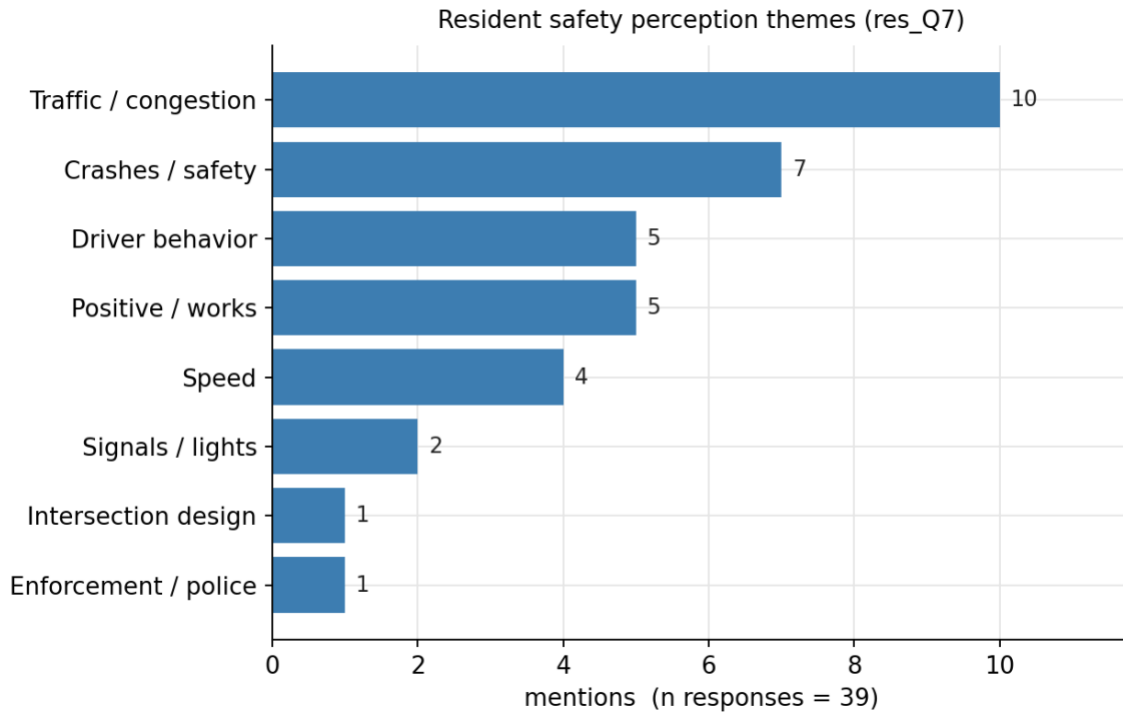


Figure 36: Plot. Theme coding of resident safety perception responses

The themes do not concentrate on RCUT geometry. Residents describe the safety problem in terms of traffic volume, driver behavior, and speed. The RCUT design itself is rarely the framing, which is consistent with the priming concern documented in the instrument design section. Once respondents are not prompted with RCUT specific imagery, they discuss the corridor as a road, not as a contested intersection design.

The recommendation themes map onto the project enhancement methods. Signal related mentions point to Method 1, traffic management to Methods 2 and 3, and pedestrian improvements to Method 5. The resident open ends, like the business open ends, line up with the enhancement methods documented in the project conclusion rather than against them.

Field observations across sites

During interviews, RCUT 5 yielded more respondents than RCUT 4, and the surveyor noted a meaningful difference in public perception between the two sites. At RCUT 4 and RCUT 91 respondents generally expressed frustration with the intersection, citing concerns about access and safety. At RCUT 5, by contrast, respondents more often reported feeling safe entering and exiting the plaza. A broader pattern emerged across the field effort. Sites where the minor road carried free flowing traffic produced more safety related complaints, whereas sites where the minor road was constrained within a plaza generated fewer. This distinction is examined further in the accessibility section of the report, which considers how RCUT design concentrates inconvenience on the minor road while reducing travel time along the major road.

Interpretation of the resident sample

Residents are more favorable than business owners on RCUT safety and only modestly more negative on congestion, but the difference is within sampling noise. The open-ended responses confirm that perceived problems on these corridors are primarily framed as traffic volume and driver behavior issues rather than RCUT specific geometry complaints. That framing is useful for outreach strategy in Chapter 7, where the project recommends a pre-construction safety education program built around site specific crash history rather than generic RCUT design literature.

Cross cutting findings

The perception gap

The single most consistent finding across the survey is the perception gap between congestion and revenue. Both businesses and residents report congestion has worsened. Businesses report

flat to positive revenue and flat to positive customer volume. The Wilson confidence intervals separate these directions with confidence even at the available sample sizes, especially on the volume and resident safety items. The perception gap is the survey contribution to the project finding that anticipated economic harm exceeds realized economic harm at the sampled corridors.

RCUT 5 versus RCUT 91

RCUT 5 (south of Atlanta, plaza constrained, signalized, with a pedestrian crossing) and RCUT 91 in Alto (north of Atlanta, free flow minor road, unsignalized, with no pedestrian crossing) carry 43 responses each, which is the only balanced site contrast in the dataset. The plaza constrained, signalized site returns the more positive picture on revenue, customer volume, and resident safety. The free flow, unsignalized Alto site returns the less positive picture across the same items, although the cross-tabulation tests do not reach significance at this sample size. The same site shows the less favorable perception in the survey and the most negative measured economic outcome in the quantitative analysis. That triangulation across measurement modes at a single corridor is the strongest project within site evidence.

CHAPTER 7. IMPLEMENTATION PLAN

This chapter presents the implementation framework derived from the study findings for use by GDOT planners, operations engineers, and district staff. The RCUT Decision-Making Tool and the Enhancement Methods and Implementation Actions sections together identify high-impact site conditions and the design and operational interventions that address them. The Community and Business Outreach section describes the recommended pre-construction, construction, and post-installation communication process. The chapter concludes with the GDOT Implementation Roadmap for tool deployment, training, pilot application, and long-term calibration.

7.1 RCUT DECISION MAKING TOOL

Categories	Description	Less Suitable (High Impact)	Neutral	Suitable (Low Impact)
1.1 Traffic Volume and Demand	Volume on the minor road, threshold disqualifier. [15]	(Minor road AADT/total AADT) > 0.3 (HIGH)	(Minor road AADT/total AADT) 0.20-0.30	(Minor road AADT/total AADT) ≤ 0.20 (LOW)
	Volume on the major road. Proposed screening volume thresholds [18]	Low major road AADT (< 15,000). Limited pass-by customer pool	Moderate major road AADT (15,000-45,000)	High major road AADT (> 45,000 vpd). Large pass-by pool.
	Heavy Vehicle and Truck Percentage [15]	High Truck and Heavy Vehicle AADT percentage (>15%)	Moderate Truck and Heavy Vehicle AADT percentage (5-15%)	Moderate Truck and Heavy Vehicle AADT percentage (<5%)
	Directional split during peak hours [15]	High volume in one direction with commercial land on high-friction side	Moderate imbalance	Balanced, or commercial on low-friction side
1.2 Speed and Operations	Posted speed limit on the minor road [15, 18]	55 mph and above	35-45 mph	Below 35 mph
1.3 Cross Section and Geometry	Right of way constraints [18]	Tight ROW (limits mitigation options)	Moderate	Generous ROW
1.4 Accessibility, and Detour Burden	Available corridor length for U-turn crossover placement. Longer corridor allows bay to be positioned closer to the intersection.	Short (< 500 ft), little design flexibility, bay must be placed far from intersection relative to available space, concentrates impact on nearest businesses	Medium (500–1,000 ft)	Long (> 1,000 ft) designer has room to position the bay close to the intersection, minimizing detour
	Detour distance to nearest (proposed) U-turn crossover [3, 15]	>1.0-mile	0.5-1.0 mile	<0.5 mile
	Proximity to alternate U-turn points or signals	No nearby signals or median openings	Some alternatives available	Closely spaced openings or nearby signal reduces detour burden
1.5 Compensatory Access	Minor road access type [2]	Free-flow-through minor road continues as live through-street; every former left turn becomes a real detour. See Appendix C Figure 38	Mixed	Plaza-constrained: minor road dead-ends into commercial plaza with internal circulation; left turn rarely used. See Appendix C Figure 37
	Exit Access onto the Major Road [15]	Single egress point onto minor road only; no alternative exit routes onto the major road	Secondary egress present but limited (not accessible, shared driveway)	Multiple egress points onto the major road
1.6 Multimodal Infrastructure	Pedestrian and bicycle infrastructure near commercial corridors. [15]	No sidewalks, crosswalks, or transit stops present near the adjacent commercial intersection	Some pedestrian infrastructure present near commercial intersections	Full pedestrian and bicycle connectivity present or planned near commercial intersection
1.7 Business Vulnerability Type	Identify business categories within the 4 intersection quadrants (NW, NE, SW, SE) [2]	High Impulse: Gas stations, convenience stores, fast food, drive-through, quick service Present in one or more quadrants	Medium Impulse: Sit-down restaurants, local services, auto-oriented retail Present in one or more quadrants	Low Impulse: Medical/dental offices, professional offices, schools, churches, government offices. Dominant business type

7.2 ENHANCEMENT METHODS

Method 1) RCUT Signalization Enhancement

Construct an additional U-turn crossover (median opening) serving the HIGH-impulse quadrant, located as close to the intersection as geometry, queuing analysis, and design speed permit.

Method 2) High Impulse Business U-Turn Placement

Impulse businesses such as gas stations, convenience stores, and drive-through establishments depend on spontaneous customer decisions, meaning even small increases in detour distance cause steep drop-offs in entry probability. The distance from the intersection to the nearest U-turn crossover is the single most impactful design variable for this business type, as it directly determines how far a displaced customer must travel before they can complete a U-turn and access the business.

The length of the U-turn lane itself is governed by roadway speed and expected queue storage requirements and should not be conflated with bay placement distance. Where high impulse businesses are present in one or more quadrants, the U-turn crossover serving those quadrants should be positioned as close to the intersection as roadway geometry, queuing analysis, and design speed permit, prioritizing proximity to the intersection over other placement considerations.

Method 3) Compensatory Access and Exits

Enhancement action: where two vulnerable businesses sit on the same side of the intersection, establish a cross-access easement so customers can reach both without re-entering the major road network.

Rather than adding secondary egress points, the placement and design of existing exits should be evaluated to serve both U-turn bound drivers and right turn only drivers without conflict.

Method 4) Wayfinding Signage

Clear and well-placed directional signage provides needed assistance at RCUT intersections to guide displaced drivers to the nearest U-turn crossover and inform approaching minor road traffic of available route options before they commit to a movement. This can help reduce driver confusion, minimizing unintended wrong way maneuvers. Providing clearer destination guidance can improve both actual accessibility and public perception, supporting both transportation efficiency and local economic activity.

Method 5) Pedestrian Infrastructure

RCUT installations that serve residential parcels or business corridors without existing sidewalks, crosswalks, or bicycle accommodations risk compounding access burdens on non-motorized users. Unlike drivers, non-motorized users cannot reroute through a U-turn crossover. Continuous pedestrian and bicycle infrastructure along the minor road approach should be provided consistent with current GDOT complete-streets practice at any RCUT site where residential or commercial land uses are present in any quadrant.

The five enhancement methods above are operationalized in the following criteria table, which maps specific trigger conditions from the decision-making screening tool to concrete implementation actions for each method.

criteria and implementation actions

Method	Trigger Conditions (From Decision Making Tool)	Enhancement Actions
Method 1 Signalized RCUT Enhancement	1.1 Minor Road AADT scores Less Suitable (>0.3 ratio) 1.2 Posted speed on minor road scores Less Suitable (≥ 55 mph) high speed increases conflict severity at unsignalized node	Install traffic signal at RCUT main intersection on major road. Where minor road volume warrants, evaluate signalization at the downstream U-turn crossover per MUTCD signal warrant analysis.
Method 2 High-Impulse Business U-Turn Placement	1.4 Detour distance to nearest U-turn crossover scores Less Suitable (> 1.0 mile), and Available corridor length scores Less Suitable (< 1640 ft), limited design flexibility 1.5 Minor Road access type scores Less Suitable (free-flow-through) 1.7 HIGH Impulse tier present in one or more quadrants	Construct an additional U-turn crossover (median opening) serving the HIGH-impulse quadrant, located as close to the intersection as geometry, queuing analysis, and design speed permit. Where two quadrants both contain HIGH impulse businesses, prioritize the quadrant with higher disrupted customer volume based on turning movement counts or trade area estimates. See Appendix C Figure 40
Method 3 Compensatory Access	1.4 Detour distance scores Less Suitable (> 1.0 mile) 1.5 Minor Road access type scores Less Suitable (free-flow-through, no alternative exits) 1.5 Exit access onto major road scores Less Suitable (single egress point only) 1.7 HIGH or MEDIUM impulse tier present in two or more quadrants on the same side of the intersection	Verify that internal cross-access easement between two quadrants is accessible to allow individuals to drive through quadrants If site conditions permit, evaluate the feasibility of a secondary egress point from the commercial plaza onto the major access road to reduce reliance on the minor road approach and provide customers with an alternative exit route.
Method 4 Wayfinding Signage	1.4 Detour distance scores Less Suitable (> 1.0 mile) 1.7 ANY tier present (HIGH, MEDIUM, or LOW impulse) in one or more quadrants 1.7 RESIDENTIAL tier, residential parcels present on minor road approach	Install U-Turn wayfinding signage in median on major road downstream of main intersection to guide displaced customers to nearest U-turn crossover. Install directional wayfinding signage on the minor road approach in advance of the RCUT intersection to inform drivers of available route options and U-turn crossover locations before they commit to a movement on the major road. See Appendix C: Figure 41
Method 5 Pedestrian Infrastructure	1.5 Minor Road access type scores Less Suitable or Neutral (free-flow-through or plaza-constrained) 1.6 No pedestrian or bicycle infrastructure present near commercial corridors 1.7 Commercial businesses present in at least one north quadrant (NW or NE) AND at least one south quadrant (SW or SE), creating cross-major-road pedestrian demand between commercial destinations	Evaluate sidewalk or shared-use path continuity along the minor road to maintain non-motorized access for residents. Add pedestrian crossing and bicycle accommodation at the RCUT node, including crosswalks, pedestrian signal heads, and bike lane continuity. Coordinate with local planning to ensure residential notification and public engagement before RCUT construction.

These enhancement rules apply to both existing and future RCUT installations. At existing locations, they provide a structured basis for retrofit improvements where monitoring or community feedback has identified unresolved access, economic, or safety impacts. At future locations, early application of the screening criteria allows enhancements to be designed in from the outset, avoiding the higher cost and disruption of post-construction remediation.

With the screening tool and enhancement criteria established, the following outreach recommendations address how GDOT should communicate with affected businesses and communities before, during, and after RCUT installation to reduce opposition rooted in misinformation and ensure that realized impacts are documented and acted upon.

7.3 COMMUNITY AND BUSINESS OUTREACH

The following outreach approaches are recommended for GDOT to adopt as standard practice at future RCUT locations.

Pre-construction engagement and perception gap communication

GDOT should incorporate RCUT-specific access and detour information into its existing Plan Development Process (PDP) public outreach for businesses within a half mile of a proposed RCUT before the design is finalized. Outreach should include a plain language summary of the proposed design, the expected detour geometry for each affected approach direction, and the enhancement measures that will be incorporated to mitigate access impacts.

A data driven RCUT safety education program should be developed and prioritized as a foundational component of pre-construction community engagement, delivered to local businesses, residents, and community stakeholders before construction begins. The safety

education program should communicate not only the magnitude of crash reductions documented at RCUT sites, but also their practical significance by presenting site specific crash history data at the proposed intersection to demonstrate why the existing design is inadequate. This evidence to local stakeholders reframes the RCUT conversation from one centered exclusively on access concerns to one that accounts for the documented safety benefits the design delivers to the businesses, customers, employees, and residents who use the corridor every day.

Informational materials should clearly convey the documented gap between anticipated and realized impacts. The Georgia findings, alongside the Louisiana and North Carolina results, which similarly document that pre-construction fears were not borne out in measured economic outcomes, provide local businesses with a credible and evidence-based counterpoint to concerns circulating in the community.

Providing this information early gives businesses an objective basis for understanding the proposed change and reduces opposition rooted in misinformation or unverified concerns.

Outreach Action	Timing	Content
Direct business notification letter	Before design finalization	Plain language summary of proposed design, expected detour geometry by approach direction, and enhancement measures being incorporated
Safety education program	Before construction begins	Before and after crash data from Georgia RCUT sites and national literature, site-specific crash history, FHWA crash modification factors
Site-specific crash history presentation	Pre-construction public meeting	Documented crash record at the existing intersection demonstrating why RCUT conversion is the recommended design solution
Perception gap communication	Before design finalization	Georgia, Louisiana, and North Carolina findings documented that measured economic outcomes at commercial corridors following RCUT installation show predominantly null results, providing businesses with an evidence-based counterpoint to pre-construction concerns.
Public project webpage	Before construction, updated throughout	Project design summary, safety evidence, enhancement measures, construction timeline, named district contact information

Construction Period Communication

Businesses should receive regular updates during the construction period identifying expected disruption timelines, temporary access arrangements, and the anticipated date of return to normal operations. The Texas DOT study found that the construction phase produces the most significant perceived impacts and that businesses present through the full before, during, and after period reported outcomes substantially better than those surveyed only before construction [8]. Consistent communication during this period helps businesses plan accordingly and reduces the likelihood that temporary construction impacts are interpreted as permanent access losses.

Post-installation Period

Where resources permit, GDOT may conduct a one-time post-construction review with businesses to document realized impacts, identify access concerns that would justify retrofit RCUT enhancements, and update the statewide RCUT database with site-level outcome data. This follow up serves both as an accountability mechanism and as a source of data for future studies. Beyond outreach, the findings of this study point to several analytical and data gaps that future research should address to strengthen both the decision-making guideline and the broader evidence base for RCUT economic impact assessment in Georgia.

The post-installation follow-up protocol described above is itself a form of ongoing data collection that feeds directly into the future research agenda. The ten future research recommendations presented in Section 8.4 identify the analytical extensions that would strengthen the decision-making guideline and expand the Georgia evidence base as new RCUT installations are added statewide.

7.4 GDOT IMPLEMENTATION ROADMAP

The decision-making tool, enhancement criteria, and outreach process presented in the preceding sections form the technical core of the implementation framework. To translate these analytical products into GDOT practice, this section describes a four-component roadmap covering tool deployment, staff training, pilot application, and long-term calibration. The roadmap is designed to operate within GDOT's existing project development workflow rather than to require new institutional structures.

Tool Deployment

The RCUT screening tool, implemented as a documented Excel workbook with separate input, calculation, and output sheets, is the primary deliverable intended for field use. GDOT should host the tool on an internal platform accessible to district planning and traffic engineering offices, with version control managed centrally to ensure that all districts are working from the same release. The most natural insertion point in the project development process is during the concept stage, before geometric design is finalized. Application of the screening tool at this stage allows the site characteristics across the seven categories to be evaluated when the proposed intersection configuration, surrounding land use, and traffic projections are first compiled. The resulting suitability classification then informs whether the RCUT alternative can advance without additional economic analysis, whether it should advance with the recommended enhancements from Section 7.2, or whether the site warrants a more detailed economic study before design is finalized.

Staff Training

Initial training should be delivered to district traffic engineers, district planners, and project managers as a structured workshop covering the screening tool's input requirements, scoring logic, and output interpretation. The workshop should include a walkthrough of at least one Georgia case study drawn from the four primary pairs analyzed in this study, demonstrating how the screening tool classifies the site and how the enhancement criteria map to the impacts documented in Chapter 6. The Georgia Tech research team should deliver the initial round of training in coordination with GDOT, with subsequent rounds transitioned to internal GDOT instructors once a cohort of district staff has been trained. A standalone user guide, separate from

this report, should accompany the workbook to support self-paced reference use between training sessions and to onboard new staff as district personnel rotate.

Pilot Application

Two to three RCUT projects already in the design phase should be selected for pilot application of the full implementation framework. Pilot sites should reflect the range of Georgia contexts represented in this study and should include at least one site with substantial commercial frontage and at least one rural site with dispersed land use. For each pilot, the screening tool should be applied during concept design, the enhancement criteria should inform geometric and operational design choices, the outreach protocol described in Section 7.3 should be executed in full, and the six- and twelve-month post-installation follow-ups should document realized impacts using the proxy measures developed in this study, including assessed property values, VIIRS nighttime radiance, and stakeholder surveys. The pilot results should be compiled into a brief evaluation report that documents both the effectiveness of the framework and any procedural refinements that field application reveals.

Long-Term Calibration

The decay coefficients, suitability thresholds, and business vulnerability tiers presented in this study are calibrated to a four-site primary sample observed within a relatively narrow post-installation window. As additional RCUTs are constructed in Georgia and as more years of post-installation data accumulate, the empirical basis for these parameters will broaden. A formal recalibration cycle of approximately five years is recommended, with the first cycle initiated once at least three pilot sites have completed twelve-month post-installation monitoring. Each calibration cycle should re-estimate the decay coefficients, revisit the baseline impulse-stop

probability values for the three business vulnerability tiers, and review the suitability thresholds in the screening tool against the updated evidence base. The statewide RCUT database, populated through the post-installation follow-up protocol described in Section 7.3, provides the foundation for this work, and maintaining this database as a permanent GDOT data asset rather than as a one-time research deliverable is essential to the long-term value of the implementation framework.

The four components above are sequential in the early years of implementation but become parallel in steady state. Tool deployment and initial training establish the foundation; the pilot phase generates internal evidence of effectiveness; and the recurring calibration cycle ensures that the tool continues to reflect Georgia conditions as the statewide population of RCUT sites grows. **Table 25** summarizes the recommended timing and lead responsibility for each component of the roadmap.

Table 20: GDOT RCUT Implementation Roadmap Components

Component	Recommended Timing	Lead Responsibility
Tool Deployment	Within six months of report acceptance	GDOT central office, in coordination with the State Traffic Engineering Office
Staff Training	Initial round within twelve months of tool deployment; refresh cycle every two to three years	Georgia Tech research team (initial); GDOT Traffic Engineering Office (subsequent)
Pilot Application	Two to three RCUT projects already in design selected within twenty-four months	GDOT district offices, in coordination with the State Traffic Engineering Office
Long-Term Calibration	Recurring five-year cycle; first cycle initiated once three pilot sites complete twelve-month post-installation monitoring	GDOT, in coordination with academic research partners

CHAPTER 8. CONCLUSIONS

This study completed four work tasks: a literature review of RCUT performance and prior state Department of Transportation (DOT) studies, a quantitative economic impact analysis at four primary treatment–control pairs in Georgia, an accessibility analysis using an exponential distance-decay model, and a stakeholder survey of businesses and residents used as supporting evidence. This chapter draws together the research contributions, the key findings as they relate to the study objectives, the limitations that qualify those findings, and the recommendations for future research. The implementation framework derived from the findings, including the decision-making tool, the enhancement criteria, and the community and business outreach process, is presented separately in Chapter 7.

8.1 RESEARCH CONTRIBUTIONS

This study contributes to the existing body of RCUT economic and access management research in three areas: methodology, empirical evidence, and policy guidance for GDOT.

The methodological contribution is a cross-method triangulation framework that combines parcel-level property valuation difference-in-differences (DiD), Visible Infrared Imaging Radiometer Suite (VIIRS) Modified Interrupted Time Series (MITS), an exponential distance-decay model for impulsive customer entry probability, and a qualitative survey of business owners and area residents. The framework was developed to operate in the absence of business-level sales tax data, which is not available at the parcel granularity that supported the Louisiana RCUT study. The distance-decay model translates RCUT geometry, including U-turn crossover distance, additional turn count, and business vulnerability tier, into a directional per-route entry

probability penalty that can be applied at the screening stage before an installation is constructed. The framework is transferable to other states facing similar data constraints.

The empirical contribution is the first Georgia-specific evidence base for the economic and accessibility consequences of RCUT installations. Four primary treatment–control pairs spanning the mountain, piedmont, and coastal plain regions of the state were analyzed, with four secondary pairs supplementing the property valuation results through VIIRS-only methods. The findings document the directional asymmetry of access impacts across the eight directional approaches per intersection and identify U-turn crossover placement distance as the single largest design lever available for mitigation.

The policy contribution is a structured decision-making tool, a set of enhancement criteria with linked implementation actions, and a community and business outreach process for use by GDOT engineers during planning, design, and construction of RCUT projects. These deliverables are presented in detail in Chapter 7.

8.2 KEY FINDINGS

This section summarizes the principal findings of the study, organized by the four research objectives stated in Section 1.3. Detailed estimates, confidence intervals, and diagnostic tests for each finding are reported in Chapter 6.

Objective 1: Business accessibility relative to an RCUT. The exponential distance-decay model shows that RCUT geometry reduces the probability of impulsive customer entry primarily on minor-road cross and left-turn movements, while major-road pass-by traffic retains full access. The loss is directionally asymmetric across the four approaches of an intersection, and U-turn crossover placement location is the single largest design lever for mitigation: shorter

crossover distances recover a substantial share of the modeled accessibility loss. Because the model is a purely geometric, literature-calibrated upper bound, it identifies worst-case exposure rather than realized measurable negative economic impact.

Objective 2: Economic data and corridor-level trends. Across the four primary pairs, the pooled property-value difference-in-differences (DiD) estimate is statistically indistinguishable from zero, and three of four pairs return null results. A localized negative effect appears at one light-industrial corridor (Alto, Pair 88), where the property-value and nighttime-light methods agree in direction and significance. Under verified commercial-zoning classification, the pooled commercial estimate is positive and significant, concentrated at Warner Robins (Pair 90). No individual pair contributes a significant negative commercial estimate.

Objective 3: Economic trends by common business type. High-impulse businesses that depend on spontaneous pass-by trips, such as gas stations, convenience stores, and quick-service restaurants, are the most exposure-sensitive category in the accessibility model. Destination-oriented businesses serving planned or appointment-based trips are least sensitive. The survey detected no significant differences in economic outcomes by business type, so this finding rests on the accessibility model rather than on observed revenue data.

Objective 4: Expected changes upon RCUT installation. RCUT installations in Georgia show consistent safety benefits (Appendix D) and mixed, mostly negligible economic effects

8.3 LIMITATIONS

Analysis Limitations

The findings of this study are subject to several limitations that arise from data availability constraints, methodological design choices, sample size, and the temporal scope of the post-installation observation window. These limitations do not invalidate the central conclusions, but they qualify the strength of inference that can be drawn from any single result and motivate several of the future research recommendations in section 8.4.

Data Availability Limitations

Absence of business-level sales tax data. The most direct measure of business economic performance, parcel- or business-level sales tax records, was not available for this study. Under O.C.G.A. § 48-2-15, the Georgia Department of Revenue cannot release tax information at any geographic resolution finer than the county level. County-level aggregates contain hundreds of taxable establishments across dozens of corridor types and cannot isolate intersection-specific changes. This forced the study to rely on three proxy measures, parcel-level assessed property values, VIIRS nighttime radiance, and stakeholder survey responses, rather than direct revenue data. The Louisiana DOT study, which did obtain anonymized business-level sales tax records, remains the only RCUT economic analysis grounded in administrative revenue data, and the present study cannot replicate that benchmark in Georgia.

Property value data depth. qPublic provides approximately four to five years of historical assessed values, which constrained both the temporal window and the sample structure for the property analysis. The four primary pairs (63, 79, 88, 90) supported a two-year pre and two-year post window with parcel coverage across the full 0.5-mile buffer, but the four secondary pairs

(14, 53, 71, 93) yielded only five to seven parcels per side after manual records requests. This sample is too small for parcel fixed-effects regression and required the simpler per-parcel log-change estimator described in Chapter 3, which has substantially less statistical power than the panel DiD specification used at the primary pairs.

Assessed values versus transaction prices. Assessed property values are an indirect indicator of market behavior. They update on county reassessment cycles and tend to lag actual sales by at least one cycle, which means that even where the RCUT did affect transaction prices, the assessed value record may not yet reflect that change within the two-year post-installation window. Where sales transaction data were available, sample sizes within the buffer were too sparse to support a parallel transaction based DiD specification.

VIIRS spatial resolution. The VIIRS Day/Night Band at the 0-feet and 330-feet buffers, the analysis is effectively reading the same pixels, and the 1640-feet buffer covers only three to five pixels. This resolution is too coarse to attribute radiance changes to individual businesses or parcels and limits the analysis to corridor-level signal detection. The buffer dilution check partially addresses this by examining whether observed effects attenuate with distance. Utilizing VIIRS as an economic proxy only allows for a corridor level analysis, it cannot determine individual businesses.

Methodological Limitations

Buffer asymmetry between methods:

The primary property DiD uses a 0.5-mile (~800ft) buffer, while the VIIRS MITS uses 0, 330, and 1640ft buffers. The cross-method comparison therefore averages over different economic footprints. The matched-buffer diagnostic at 1640ft partially resolves this, but only Pair 79 has

both treatment and control coordinates available at 1640ft, so it is the only pair where a cross-method comparison can be run at a shared spatial scale.

Decay model parameters drawn from literature

The customer entry decay model uses fixed coefficients ($k_d = 0.50$ per mile and $k_t = 0.30$ per extra turn) drawn from the access management literature rather than empirically calibrated to Georgia conditions. Pass-by capture rates from the ITE Trip Generation Manual and Gluck et al. (1999) are similarly imported. The decay model is therefore best understood as a worst-case geometric upper bound: it quantifies the maximum impulsive demand loss imposed by RCUT geometry. Pair 79's null economic outcome despite a predicted ~59% loss illustrates this gap.

Survey location, priming and survivorship bias

Despite the question-ordering protections built into the instrument (described in Chapter 5), survey respondents are people who still visit the corridor; customers who rerouted or stopped coming after RCUT installation are not represented. Similarly, businesses that closed before survey administration are absent from the business sample, which would attenuate any negative revenue signal that did exist. The pilot administration confirmed that early RCUT-specific framing produces uniformly negative responses, but residual priming from corridor signage, recent media coverage, or word-of-mouth cannot be fully ruled out.

Survey response rate on the revenue question

Only 12 of 38 business respondents (31%) provided a substantive answer to the revenue question. The 69% nonresponse rate raises the possibility that nonresponses differ systematically from responders, particularly if businesses experiencing revenue declines were less willing to disclose financial information. The Wilson confidence interval on the revenue-improved share

(19.3% to 68.0%) is wide enough that a single additional decline response would shift the headline percentages noticeably. The customer-volume item, with twice the substantive sample, supports stronger inference.

Survey and quantitative sites do not overlap

Survey responses were collected at RCUTs 4, 5, and 91, while the property value and VIIRS analyses cover Pairs 63, 79, 88, and 90. The two sets of findings are directionally consistent but not site-matched, so the survey results function as supplementary qualitative evidence rather than as direct corroboration of the quantitative results at any single intersection.

Sample Size and Statistical Power

Limited number of treatment sites

Only eight RCUT pairs (four primary and four secondary) were retained after applying the screening criteria, out of approximately 49 RCUT installations statewide. Heterogeneous findings across sites are plausible given the variation in corridor type, AADT, land use mix, and U-turn crossover configuration, but the small sample limits the precision with which subgroup patterns can be estimated and constrains the external validity of any single-pair finding.

Temporal Scope and External Conditions

Short post-installation window

Several treatment sites were installed in 2022 or 2023, leaving only one to two years of post-installation observations as of the analysis cutoff. Both the access management literature and the Texas DOT raised-median study suggest that business and customer adaptation can take three to

five years, particularly for impulsive-trip-dependent businesses that may relocate or change format in response to access changes. The current window may therefore underestimate long-run effects in either direction.

COVID-19 and post-pandemic recovery confounding

Multiple installation years overlap with the post-pandemic economic recovery period (2021-2024). Although the matched control design absorbs statewide and county-level shocks common to both treatment and control corridors, highly localized recovery patterns, including changes in commuting behavior, retail trade composition, and commercial real estate demand, may still bias individual pair estimates if they affected treatment and control corridors differently. None of the primary pairs is fully clean of this concern.

Construction-period effects not separately estimated

The installation calendar year is excluded from both pre- and post-windows in the property and VIIRS specifications to prevent construction noise from contaminating either period, but this also means the analysis cannot characterize the construction phase itself. The Texas DOT raised-median study identified construction as the most disruptive period for adjacent businesses, and a separately estimated construction-phase effect would strengthen the policy-relevant interpretation of the post-installation results.

Generalizability

Multimodal user perspectives underrepresented

The resident survey is dominated by car users (49 of 59 respondents, 83%). Pedestrian and bicycle perceptions are not represented in the sample, and the decay model and accessibility

analysis do not address non-motorized user experience. RCUT installations on corridors with residential land uses or planned multimodal connectivity may impose access burdens on non-motorized users that this study does not measure.

8.4 RECOMMENDATIONS FOR FUTURE RESEARCH

1. **Update and complete the existing statewide RCUT database.** A preliminary database already exists and supplied the RCUT locations for RP 24-12; assign district-level stewardship and populate the pilot pairs as verified records so that future analyses do not repeat the data-assembly work performed in this study.

Expand field-based accessibility data collection and conduct periodic or one-time follow-up observation of business composition where resources permit by type at RCUT

corridors. The current accessibility analysis relies on geometric measurements and assumed entry probabilities. Future work should deploy turning movement counts, driveway volume counts, and customer intercept surveys at a broader set of RCUT sites to empirically calibrate the decay model parameters (p_0 and α) by business vulnerability tier. In addition, GDOT should establish a periodic monitoring protocol within the RCUT database that tracks business openings, closures, and type changes within a half-mile buffer of each RCUT installation, enabling longitudinal assessment of whether access-sensitive business categories relocate or adapt over time.

2. **Obtain third-party transaction data to improve the current guideline.** Access to parcel-level credit and debit card transaction data (Dewey Data, SafeGraph) would provide a direct, high-frequency measure of business volume change that property values and VIIRS cannot

capture. Obtaining data that can capture transaction changes and distinguishes business type can further the business type impact.

3. **Extend the post-installation window to five years.** Revisit the pilot pairs three to five years post-installation and rerun the DiD and MITS specifications on the extended panels. Assessed values capitalize access changes slowly, one to two years post is not a stable equilibrium.
4. **Conduct a longitudinal perception and behavioral survey.** The survey captured a cross-sectional snapshot of customer perception at treated and control sites. A panel survey that re-contacts the same business owners and customers at 1-year and 3-year intervals would distinguish temporary adaptation effects from permanent behavioral change particularly relevant for whether wayfinding improvements reduce perceived access friction over time.
5. **Pair VIIRS with higher-resolution remote sensing.** Explore Planet "SkySat" daily composites and Sentinel-2 high resolution satellite to capture parked car volumes at commercial plazas and fine-grained activity changes pre and post RCUT installation.
6. **Analyze access impacts at multi-RCUT corridors.** Several Georgia corridors have two or more RCUTs in sequence. Businesses in these corridors may face additive detour effects under trip patterns that require access to parcels on both sides of the corridor, which a single-site DiD cannot fully capture.

Pedestrian and bicycle user studies. The current project did not directly observe non-motorized user experience: the resident survey was dominated by car users (49 of 59 respondents; 83%) and

included no pedestrian or bicycle respondents. Future work should directly study pedestrian and bicycle user experience at RCUT sites.

The screening tool evaluates seven site characteristics across three impact tiers: Less Suitable, Neutral, and Suitable, covering traffic volume and demand, speed and operations, cross section geometry, accessibility and detour burden, compensatory access, multimodal infrastructure, and business vulnerability type. Together these categories capture the full range of site conditions that the Georgia findings and supporting literature identify as drivers of economic impact at RCUT installations. Where the screening tool identifies sites as ‘Less Suitable’ across one or more categories, the following five enhancement methods provide targeted design and operational interventions to reduce economic impact before or after RCUT installation.

APPENDIX

APPENDIX A: SITE INVENTORY

Table 21: Treatment-Control Site Inventory

Pair ID	Tier	Role	Location (City)	Route / Intersection	County	Latitude	Longitude	Build Year
63	Primary	Treatment	nr. Blairsville	SR 515 @ SR 325 (Notely Dam Rd)	Union	34.873388	-84.079911	2022
63	Primary	Control	nr. Blairsville	SR 515 @ SR 325 (Foster Rd)	Union	34.877162	-84.109644	-
79	Primary	Treatment	Cedartown	SR 6 / US 278 @ Barber Rd / Bethlehem Rd	Polk	34.007135	-85.140936	2023
79	Primary	Control	Cedartown	SR 6 / US 278 @ Hutto Rd	Polk	34.017775	-85.206782	-
88	Primary	Treatment	nr. Alto	SR 365 @ Mud Creek Rd	Habersham	34.435950	-83.631768	2023
88	Primary	Control	Baldwin	SR 365 @ Wilbanks Rd	Habersham	34.480631	-83.587192	-
90	Primary	Treatment	Warner Robins	SR 247C @ Tom Chapman Blvd	Houston	32.614782	-83.703245	2023
90	Primary	Control	Warner Robins	SR 247C @ Peacock Dr	Houston	32.618327	-83.652305	-
14	Secondary	Treatment	nr. Sylvania	SR 301 Loop @ Buttermilk Rd/Singleton Ave	Screven	32.762184	-81.647432	2020
14	Secondary	Control	Sylvania	SR 73 @ Pine St	Screven	32.746216	-81.645505	-
53	Secondary	Treatment	nr. LaFayette	SR 1 / US 27 @ SR 151	Walker	34.595219	-85.283786	2021
53	Secondary	Control	Trion	US 27 @ Mountain View Rd	Walker	34.546263	-85.295218	-
71	Secondary	Treatment	Fayetteville	SR 54 @ Autumn Glen Cir/Rosewood Dr	Fayette	33.450861	-84.438417	2022
71	Secondary	Control	Fayetteville	SR 54 @ Corinth Rd	Fayette	33.482870	-84.403828	-
93	Secondary	Treatment	Talking Rock	SR 515 @ Antioch Church Rd	Pickens	34.507214	-84.515581	2019
93	Secondary	Control	Talking Rock	SR 515 @ Carnes MI Rd	Pickens	34.528553	-84.516605	-

Table 22: RCUT Matching Criteria

Pair	Treatment Site	Control Site	Matching Criteria
63	Blairsville, GA	Blairsville, GA	Rural - minor arterial (SR 515 / SR 325); AADT match (shared station, identical); land-use context (qualitative)
79	Cedartown, GA	Cedartown, GA	Small urban / rural-fringe; principal arterial (US 278 / SR 6); AADT match ($\pm 1,950$); land-use context (qualitative)
88	Alto, GA	Baldwin, GA	Rural - principal arterial (SR 365, 4-lane divided); AADT match (± 550); land-use context (qualitative)
90	Warner Robins, GA	Warner Robins, GA	Suburban / urban; minor arterial (SR 247C / Watson Blvd); AADT match (± 850); land-use context (qualitative)
14	Sylvania, GA	Sylvania, GA	Rural - minor arterial (SR 73 Loop); AADT match (± 105); land-use context (qualitative)
53	LaFayette, GA	Trion, GA	Rural - principal arterial (US 27 / SR 1); cross-county match (Walker / Chattooga); AADT match ($\pm 1,560$); land-use context (qualitative)
71	Fayetteville, GA	Fayetteville, GA	Suburban (Atlanta metro); minor arterial (SR 54); AADT match ($\pm 2,950$); land-use context (qualitative)
93	Talking Rock, GA	Talking Rock, GA	Rural - minor arterial (SR 515 / APD Hwy); AADT match ($\pm 1,050$); land-use context (qualitative)

Table 23: RCUT Census Classification

Pair	Role	County	Tract pop
63	Treatment	Union	3,987
63	Control	Union	3,987
79	Treatment	Polk	5,057
79	Control	Polk	5,057
88	Treatment	Habersham	5,465
88	Control	Habersham	6,809

90	Treatment	Houston	5,310
90	Control	Houston	3,493
14	Treatment	Screven	3,693
14	Control	Screven	3,693
53	Treatment	Walker	3,178
53	Control	Chattooga	3,268
71	Treatment	Fayette	3,951
71	Control	Fayette	6,372
93	Treatment	Pickens	4,533
93	Control	Pickens	4,533

1

Table 24: RCUT Minor Road AADT (Based on Availability)

Pair	Site	Minor Road AADT Pre	Minor Road AADT Post	%Δ
63	Treatment	2,785	2,450	-12.0%
79	Treatment	830	700	-15.7%
90	Control (no RCUT)	850	890	+4.7%
71	Treatment*	6,590	8,435	+28.0%

* Pair 71 minor road carries 6,000+ AADT and functions as a minor arterial. Strong local development in Fayetteville masks any RCUT redistribution signal at this site.

Table 25: RCUT pre-post AADT and Percent Change

Pair	Tier	Road	Pre avg	Post avg	% change
63 T+C	Primary	SR 515 (shared station)	8,405	9,355	+11.3%
63 T	Primary	SR 325 minor	2,785	2,450	-12.0%
79 T	Primary	US 278	14,150	14,600	+3.2%
79 T	Primary	minor	830	700	-15.7%
79 C	Primary	US 278	16,100	16,500	+2.5%
88 T	Primary	SR 365	27,450	28,700	+4.6%
88 C	Primary	SR 365	28,000	28,800	+2.9%
90 T	Primary	Watson Blvd	28,150	30,800	+9.4%
90 C	Primary	Watson Blvd	29,000	29,000	0%
90 C	Primary	minor	850	890	+4.7%
14 T	Secondary	SR 73 Loop	4,120	4,245	+3.0%
14 C	Secondary	major (corrected)	4,015	3,980	-0.9%
53 T	Secondary	US 27 / SR 1	6,595	7,170	+8.7%
53 C	Secondary	US 27 / SR 1	8,155	9,105	+11.6%
53 C	Secondary	minor	1,325	1,135	-14.3%
71 T	Secondary	SR 54 (combined)	20,850	23,325	+11.9%
71 T	Secondary	minor (= minor arterial)	6,590	8,435	+28.0%
71 C	Secondary	SR 54	17,900	22,200	+24.0%
93 T	Secondary	SR 515 (combined)	19,050	20,050	+5.2%
93 C	Secondary	SR 515 (all-actual)	18,000	19,300	+7.2%

Table 26: RCUT Frontage and Visible Businesses

Pair	Role	Setting	Adjacent Frontage	Visible Businesses
63	Treatment	Rural	Gas station (NE); convenience center (NW)	2
63	Control	Rural	Gas station (SW); country-side convenience store	2
79	Treatment	Small urban / rural-fringe	Gas station + food mart (SW); storage building (SE)	2-3
79	Control	Small urban / rural-fringe	Gas station + food mart (NW); Dollar General (NE); food dealer (SE); auto repair (SW)	4
88	Treatment	Rural	Gas station + food mart (SE)	1
88	Control	Rural (verified)	Gas station + food mart + restaurant (NE)	2-3
90	Treatment	Suburban / urban	Commercial plaza NE (restaurant, motel, personal services); medical SE; residential SW	5+
90	Control	Suburban / urban	Medical (NW); law firm (NE); medical + church (SE); fast food + home goods (SW)	5+

Table 27: RCUT Zoning Stratification

Pair	Tier	Overall Property DiD	Significant?	Zoning Verified?	Used for Stratified DiD?
63	Primary	+2.0% (p=0.76)	No	No	No
79	Primary	-1.7% (p=0.76)	No	Partial (~30%)	No
88	Primary	-24.0% (p=0.013)	Yes **	Yes (98% T, 93% C)	Yes- Residential / Industrial
90	Primary	-0.5% (p=0.87) overall; +39.8% Commercial (p=0.044)	Commercial sig *	Yes (98% T, 98% C)	Yes- Residential / Commercial / Industrial
14	Secondary	+32.4% (p=0.43)	No	No	-
53	Secondary	-27.5% (p=0.31)	No	No	-
71	Secondary	-21.0% (p=0.23)	No	No	-
93	Secondary	+12.4% (p=0.50)	No	No	-

APPENDIX B: SURVEY

Start of Block: For Surveyor

For Surveyor

- ☐ Treatment (1)
- ☐ Control (2)

End of Block: For Surveyor

Start of Block: Introduction and Survey Consent

Consent Survey You are invited to participate in a research study about travel access and experiences near selected roadway intersections. The purpose of this study is to understand how individuals who work at or visit nearby businesses perceive access, traffic conditions, and general travel experiences in these areas. If you choose to participate, you will be asked to complete a brief survey that will take approximately 5–10 minutes. The survey includes questions about your travel experiences with intersections, business operational changes, perceived changes in accessibility or traffic flow, and overall impressions of how intersections affect nearby businesses or travel. You may skip any questions and may stop participating at any time. This study involves minimal risk, like completing a routine opinion or feedback survey. There is no direct benefit to you; however, your participation may help transportation agencies and planners better understand community and business perspectives related to intersection design. No personally identifiable information will be collected. Survey responses will be anonymous or de-identified and stored securely. Results will be reported only in aggregate form, and individual participants or businesses will not be identified. Participation is voluntary. You may decline to participate or withdraw at any time without penalty or loss of benefits. You will not be compensated for joining this study. We will comply with any applicable laws and regulations regarding confidentiality. To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB may review study records. The Office of Human Research Protections may also look at study records. If you have any questions about your rights as a research subject, you may contact Georgia Institute of Technology Office of Research Integrity Assurance at IRB@gatech.edu. Thank you for participating in this study. If you have questions about the study, contact the researchers listed below. Dr. James Tsai (Georgia Institute of Technology) Consent Statement: Before accessing the survey questions, you confirm that you are 18 years of age or older, have read and understood this information, and voluntarily agree to participate in this study.

- ☐ I agree to participate in this voluntary survey (1)
- ☐ I do not agree to participate in this voluntary survey (2)

End of Block: Introduction and Survey Consent

Start of Block: Path A/B Questions

Q1 What is your primary relationship to this area?

- ☐ Business owner / manager (1)
 - ☐ Employee at a local business (6)
 - ☐ Passing-by customer or patron (2)
 - ☐ Local resident (3)
 - ☐ Daily commuter (4)
 - ☐ Other (7)
-

Display this question:

If What is your primary relationship to this area? = Business owner / manager

And What is your primary relationship to this area? = Employee at a local business

And What is your primary relationship to this area? = Local resident

And What is your primary relationship to this area? = Daily commuter

And What is your primary relationship to this area? = Other

Q2 How long have you lived, worked, or regularly visited this area?

- ☐ Less than 1 year (1)
 - ☐ 1–3 years (2)
 - ☐ 4–10 years (3)
 - ☐ More than 10 years (4)
 - ☐ Don't live here (5)
-

Q3 3. How frequently do you travel through or visit this area?

- ☐ Daily (1)
- ☐ Several times a week (2)
- ☐ Once a week (3)
- ☐ A few times a month (4)
- ☐ Rarely (5)

End of Block: Path A/B Questions

Start of Block: Path A - Business/Employees

Q4 Which best describes most of your customers?

- ☐ Mostly planned trips (customers intend to visit before starting their trip) (1)
 - ☐ Mostly convenience or impulse stops (2)
 - ☐ A mix of both (3)
 - ☐ Not sure / Prefer to not disclose (4)
-

Q5 How long has this business operated at this location?

- ☐ Less than 1 year (1)
 - ☐ 1–3 years (2)
 - ☐ 4–10 years (3)
 - ☐ More than 10 years (4)
 - ☐ Unsure/Prefer to not disclose (5)
-

Display this question:

If What is your primary relationship to this area? = Business owner / manager

And What is your primary relationship to this area? = Passing-by customer or patron

Q6 Approximately how many employees work at this location?

- ☐ 1–5 (1)
 - ☐ 6–15 (2)
 - ☐ 16–30 (3)
 - ☐ 31+ (4)
 - ☐ Unsure/Prefer to not disclose (5)
-

Q7 How do most employees typically commute to work?

- ☐ Drive alone (1)
 - ☐ Carpool (2)
 - ☐ Walk or bike (3)
 - ☐ Public transportation (4)
 - ☐ Mixed / varies (5)
 - ☐ Unsure/Prefer to not disclose (6)
-

Q8 Over the past few years, how would you describe changes in **revenue** within the past year

- ☐ Increased significantly (more than 10%) (1)
- ☐ Increased slightly (1-10%) (2)
- ☐ No noticeable change (3)
- ☐ Decreased slightly (1-10%) (4)
- ☐ Decreased significantly (more than 10%) (5)
- ☐ Prefer not to say / Not sure (6)

Display this question:

If Over the past few years, how would you describe changes in revenue within the past year = Increased significantly (more than 10%)

And Over the past few years, how would you describe changes in revenue within the past year = Increased slightly (1-10%)

And Over the past few years, how would you describe changes in revenue within the past year = Decreased slightly (1-10%)

And Over the past few years, how would you describe changes in revenue within the past year = Decreased significantly (more than 10%)

Q8.1 *Optional*: Can you give a specific numerical estimation in how much changes in monthly revenue? (Percentage Change or Dollar Amount)

Q9 On a typical day, approximately how many customers visit your business?

- ☐ Fewer than 25 (1)
 - ☐ 25-50 (2)
 - ☐ 51-100 (3)
 - ☐ More than 100 (4)
 - ☐ Unsure/Prefer to not disclose (5)
-

Q10 Over the past 2 years, how would you describe changes in **customer volume** within the past year?

- ☐ Increased significantly (more than 10%) (1)
 - ☐ Increased slightly (1-10%) (2)
 - ☐ No noticeable change (3)
 - ☐ Decreased slightly (1-10%) (4)
 - ☐ Decreased significantly (more than 10%) (5)
 - ☐ Unsure/Prefer to not disclose (6)
-

Display this question:

If Over the past 2 years, how would you describe changes in customer volume within the past year? = Increased significantly (more than 10%)

And Over the past 2 years, how would you describe changes in customer volume within the past year? = Increased slightly (1-10%)

And Over the past 2 years, how would you describe changes in customer volume within the past year? = Decreased slightly (1-10%)

And Over the past 2 years, how would you describe changes in customer volume within the past year? = Decreased significantly (more than 10%)

Q10.1 What do you think are the main reasons for that change?

Q11 Over the past few years, have you noticed customers choosing nearby alternatives instead of your business?

- ☐ Yes, more often than before (1)
 - ☐ About the same as before (2)
 - ☐ Less often than before (3)
 - ☐ Unsure/Prefer not to disclose (4)
-

Q12 Have your operating hours changed in the past few years?

- ☐ Yes, we extended Hours (1)
 - ☐ Yes, we reduced Hours (2)
 - ☐ No Change (3)
 - ☐ Unsure/Prefer not to say (4)
-

Q13 For customers to enter and exit your business by vehicle... it is:

- ☐ Extremely difficult (1)
 - ☐ Somewhat difficult (2)
 - ☐ Neither easy nor difficult (3)
 - ☐ Somewhat easy (4)
 - ☐ Extremely easy (5)
-

Q14 Have customers ever commented on getting to your business?

- ☐ Yes, mostly positive (1)
 - ☐ Yes, mostly negative (2)
 - ☐ Mixed feedback (3)
 - ☐ No, not really (4)
-

Display this question:

If Have customers ever commented on getting to your business? = Yes, mostly positive

And Have customers ever commented on getting to your business? = Yes, mostly negative

And Have customers ever commented on getting to your business? = Mixed feedback

Q14.1 If yes, what do they typically say?

Q15 Has your business made any changes in the past few years to help customers find or reach you?

- ☐ Adjusted hours (1)
 - ☐ Changed staffing or scheduling (2)
 - ☐ Added signage or directions (3)
 - ☐ Updated online directions (4)
 - ☐ Changed delivery times or freight scheduling (5)
 - ☐ No changes (6)
 - ☐ Other (7) _____
-

Q16 How has congestion changed over the past couple years?

- ☐ Significantly improved (1)
 - ☐ Slightly improved (2)
 - ☐ No change / Neutral (3)
 - ☐ Slightly worsened (4)
 - ☐ Significantly worsened (5)
 - ☐ I don't know / Not sure (6)
-

Q17 Based on your experience, traffic safety near your business is:

- ☐ Very safe (1)
 - ☐ Somewhat safe (2)
 - ☐ Neither safe nor unsafe (3)
 - ☐ Somewhat unsafe (4)
 - ☐ Very unsafe (5)
-

Q18 How often have you observed crashes or near-misses near your business?

- ☐ Frequently (1)
 - ☐ Occasionally (2)
 - ☐ Rarely (3)
 - ☐ Never (4)
 - ☐ Unsure (5)
-

Q19 Is there anything about your location or surrounding roads you'd want a transportation engineer/planner to know?

End of Block: Path A - Business/Employees

Start of Block: Path B - Community/Patrons

Q1 Which of the following is your primary mode of transportation?

- ☐ Car (1)
 - ☐ Walking/Biking (2)
 - ☐ Public Transportation (train, bus, etc) (3)
 - ☐ Other (4) _____
-

Q2 How familiar are you with traveling through this area?

- ☐ Not familiar at all (1)
 - ☐ Slightly familiar (2)
 - ☐ Moderately familiar (3)
 - ☐ Very familiar (4)
 - ☐ Extremely familiar (5)
-

Q3 When traveling to businesses in this area, do you typically use the main road directly in front, or do you use side streets to access them?

- ☐ Main road directly (1)
 - ☐ Side streets or back roads (2)
 - ☐ Combination of both (3)
 - ☐ Not sure (4)
-

Q4 Was this stop part of your original trip plan?

- ☐ Yes (1)
- ☐ Maybe/Unsure (2)
- ☐ No (3)

Display this question:

If Was this stop part of your original trip plan? = No

Q4.1 What made you decide to stop here today? (Select all that apply)

- ☐ Short on time (1)
- ☐ Convenient location (2)
- ☐ Easy to access from the road (3)
- ☐ Low traffic / Smooth traffic flow (4)
- ☐ Needed gas/food/item unexpectedly (5)
- ☐ Familiar business (6)
- ☐ Other (7) _____
-

Q5 Has congestion improved in this area the past couple years?

- ☐ Significantly improved (1)
 - ☐ Slightly improved (6)
 - ☐ No change / Neutral (7)
 - ☐ Slightly worsened (8)
 - ☐ Significantly worsened (9)
 - ☐ I don't know / Not sure (10)
-

Q6 How safe did you feel getting to your destination/stop today?

- ☐ Very safe (1)
 - ☐ Somewhat safe (2)
 - ☐ Neither safe nor unsafe (3)
 - ☐ Somewhat unsafe (4)
 - ☐ Very unsafe (5)
-

Q7 What contributes to your safety perception of this area?

Q8 If you were to talk to a safety engineer, what would be your main point or recommendation?

End of Block: Path B - Community/Patrons

APPENDIX C: GUIDELINE RCUT VISUALS

Commercial Plaza minor road constraint visual

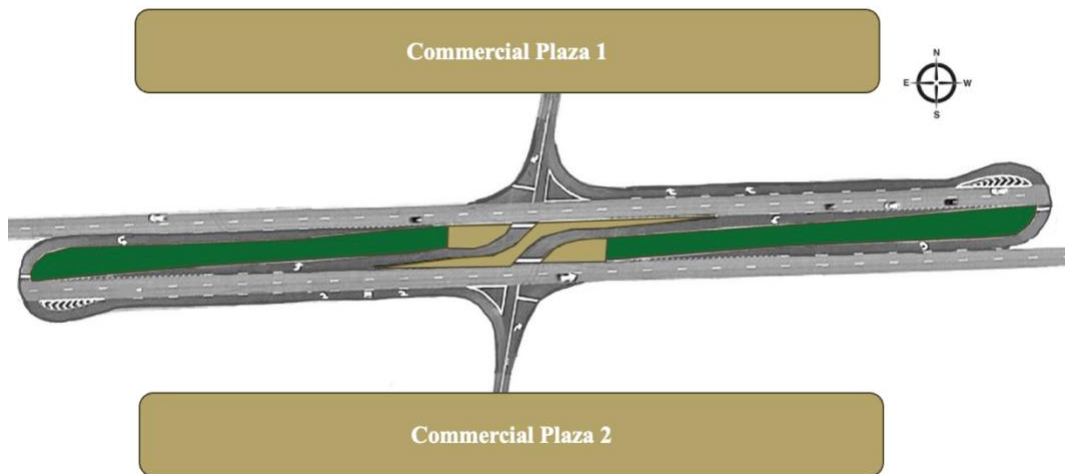


Figure 37: Diagram. Minor Road Constrained Within Commercial Plazas, and NW, SE, SW, and SE Quadrants

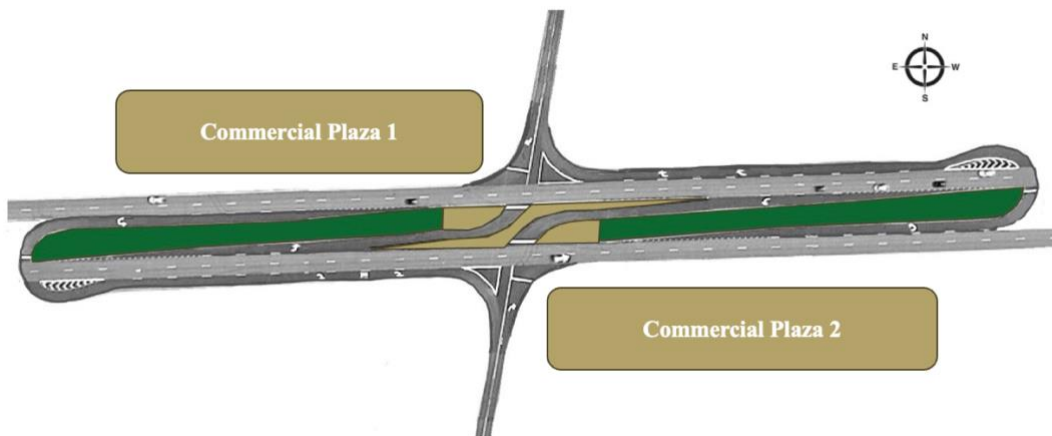


Figure 38: Diagram. Minor Road Continues as a Live-Through-Street, it is not constrained or end within two commercial plazas

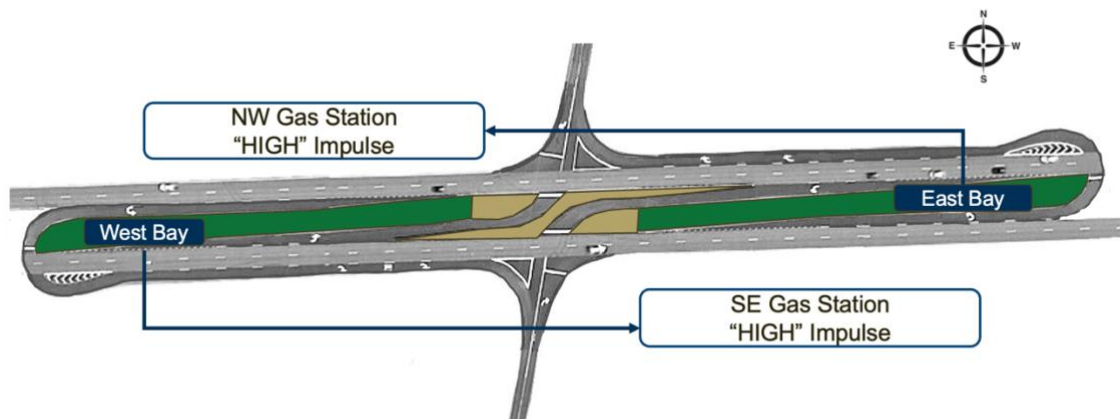


Figure 39: Diagram. U-turn crossover Placement Serves the Opposite Quadrant of the Intersection

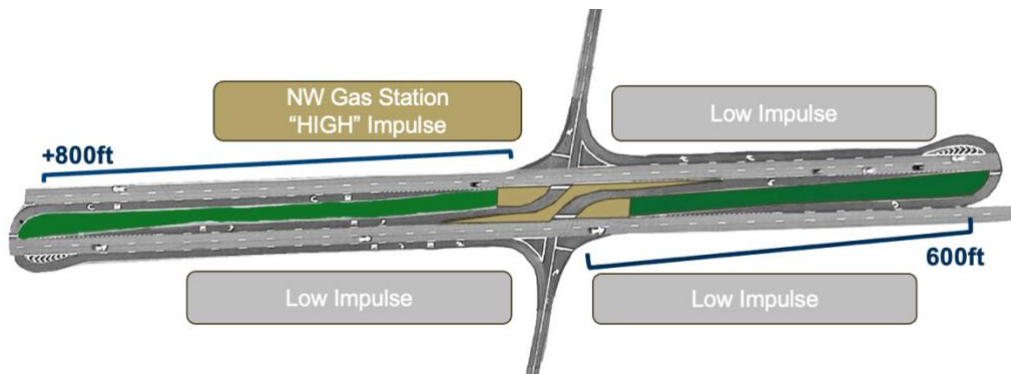


Figure 40: Diagram. Shorter distance to U-turn to offset to Serve the Opposite Quadrant

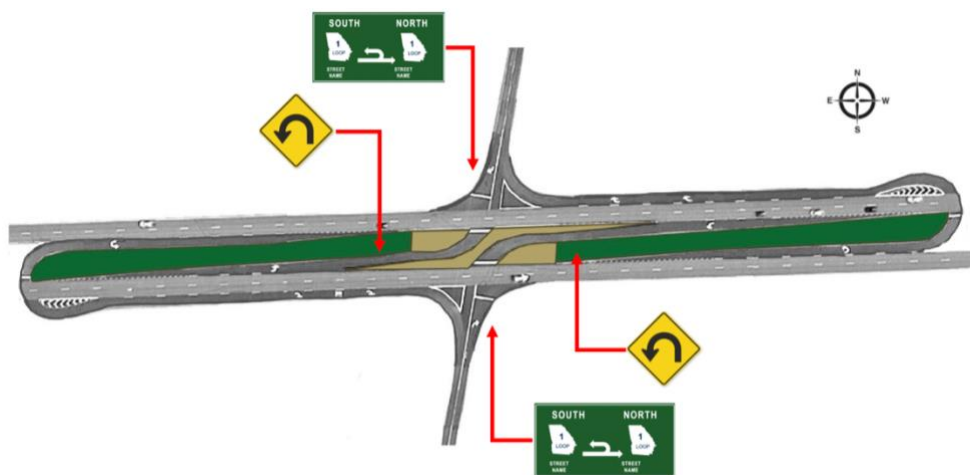


Figure 41: Diagram. Wayfinding U-turn signal placement before the U-turn crossover. RCUT maneuver signage placed on the right-side of the minor road.

APPENDIX D: SAFETY ANALYSIS

SAFETY ANALYSIS

Crashes are tagged as pre-installation, transition-year, or post-installation using each pair's build year, and classified as injury (KABCO “K”, “A”, “B”, or “C”) or property damage only (KABCO “O”).

For each pair, annual crash counts are compared before and after installation. A Welch two-sample t-test is applied to annual counts where at least two pre- and two post-installation years of data exist. The pair-level DiD estimate in crashes per year is:

$$DiD = [T_{post} - T_{pre}] - [C_{post} - C_{pre}] \quad \text{Equation 25}$$

Where T is the treatment and C is the control. Negative values indicate the treatment site improved more than its control.

CRASH ANALYSIS

GDOT crash records were pulled for the four primary pairs (63, 79, 88, 90) and the four secondary pairs (14, 53, 71, 93) for all available years through 2024. From this, 18 pair and type files produced crash rows, each with KABCO severity, manner of crash, date and time, and geocoded latitude and longitude. Each crash was tagged pre, transition, or post using the pair build year, and classified as injury (KABCO K, A, B, C) or property damage only (KABCO O). Yearly crash counts per site were the unit of observation for the pre to post comparison, as seen in **Table 28**

Table 28: Pre-Post Crash Counts for Matched Treatment and Control Site Pairs

Pair	Build	Pre years	Post years	Treatment pre / post crashes	Control pre / post crashes
14	2020	2	2	7 / 5	5 / 2
53	2021	3	3	23 / 20	29 / 24
63	2022	2	2	24 / 13	0 / 1
71	2022	2	2	8 / 7	40 / 37
79	2023	1	1	4 / 2	20 / 17
88	2023	1	1	11 / 9	6 / 4
90	2023	1	1	6 / 4	8 / 10
93	2019	2	2	16 / 14	2 / 6

Method and windows

For every pair, a yearly mean was computed separately for the treatment and the matched control intersection. Percent change was calculated, and a Welch two sample t test on yearly counts was run where both arms had at least two pre and two post years; pairs with a single post year (most of the 2023 cohort) return NaN for the t statistic and should be read as descriptive. A pair level difference in differences was computed for crashes per year.

Treatment site results

The cleanest signal in the crash data is on injury crashes. From the pairs, 7 of 8 treatment sites with measurable pre and post data show a reduction or no change in injury severity. The one exception (Pair 14) has an injury sample of one pre-crash and four post crashes, which is too small to read. The percent changes below are computed on yearly means, so they correct for the uneven window lengths in **Table 29** and **Figure 42**

Table 29: Treatment Site Pre-Post, Yearly Means and Injury Totals

Pair	Total crashes, T pre to post (per yr)	Total % change	Injury crashes, T pre to post	Injury % change
------	--	-------------------	----------------------------------	--------------------

14	3.5 to 2.5	-28.6%	0.5 to 2.0	+300% (small N)
53	7.7 to 6.7	-13.0%	5.3 to 2.7	-50.0%
63	12.0 to 6.5	-45.8%	6.0 to 0.5	-91.7%
71	4.0 to 3.5	-12.5%	1.5 to 0.5	-66.7%
79	4.0 to 2.0	-50.0%	1.0 to 1.0	0.0%
88	11.0 to 9.0	-18.2%	5.0 to 3.0	-40.0%
90	6.0 to 4.0	-33.3%	5.0 to 2.0	-60.0%
93	8.0 to 7.0	-12.5%	5.0 to 2.0	-60.0%

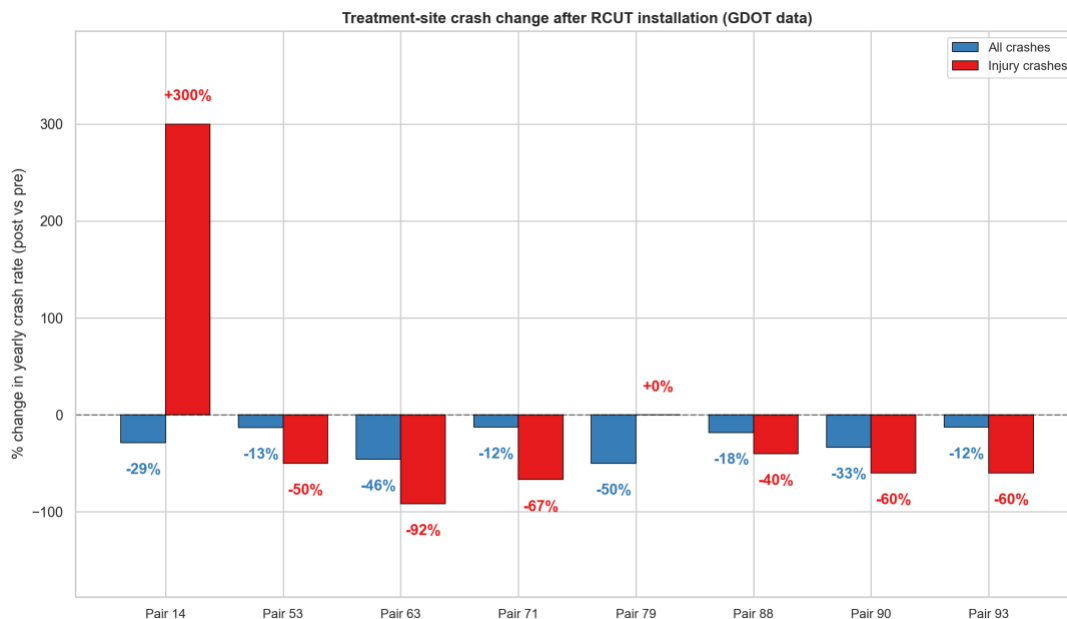


Figure 42: Plot. Treatment site percent change in yearly crash rate, total crashes (blue) and injury (red)

Pair level difference-in-differences

The DiD in crashes per year is the quantity most directly comparable to the published RCUT literature. Negative values mean the treatment intersection improved more than its control over the same window. Of total crashes, 4 of 8 pairs (63, 71, 90, 93) show negative or null results. Pair 63 had the largest reduction at -6.0 per year, followed by Pair 90 at -4.0 per year and Pair 93 at -3.0 per year. Pairs with positive results were small in magnitude, at +1.0 per year or less. On injury crashes, 5 of 8 pairs (63, 71, 79, 90, 93) show negative or null results. Pair 63 again led with a reduction of -5.5 per year, followed by Pair 90 at -5.0 per year and Pair 93 at -4.0 per year.

Positive DiD results were small in magnitude, at +2.5 per year or less, as seen in **Table 30** and **Figure 43**.

Table 30: Pair level DiD in Yearly Crash Rates

Pair	T Δ crashes/yr	C Δ crashes/yr	DiD crashes/yr	T Δ injury/yr	C Δ injury/yr	DiD injury/yr
14	-1.00	-1.50	+0.50	+1.00	-1.50	+2.50
53	-1.00	-1.67	+0.67	-1.00	-1.33	+0.33
63	-5.50	+0.50	-6.00	-5.50	0.00	-5.50
71	-0.50	-1.50	+1.00	-2.50	0.00	-2.50
79	-2.00	-3.00	+1.00	0.00	0.00	0.00
88	-2.00	-2.00	0.00	-3.00	-4.00	+1.00
90	-2.00	+2.00	-4.00	-3.00	+2.00	-5.00
93	-1.00	+2.00	-3.00	-4.00	0.00	-4.00

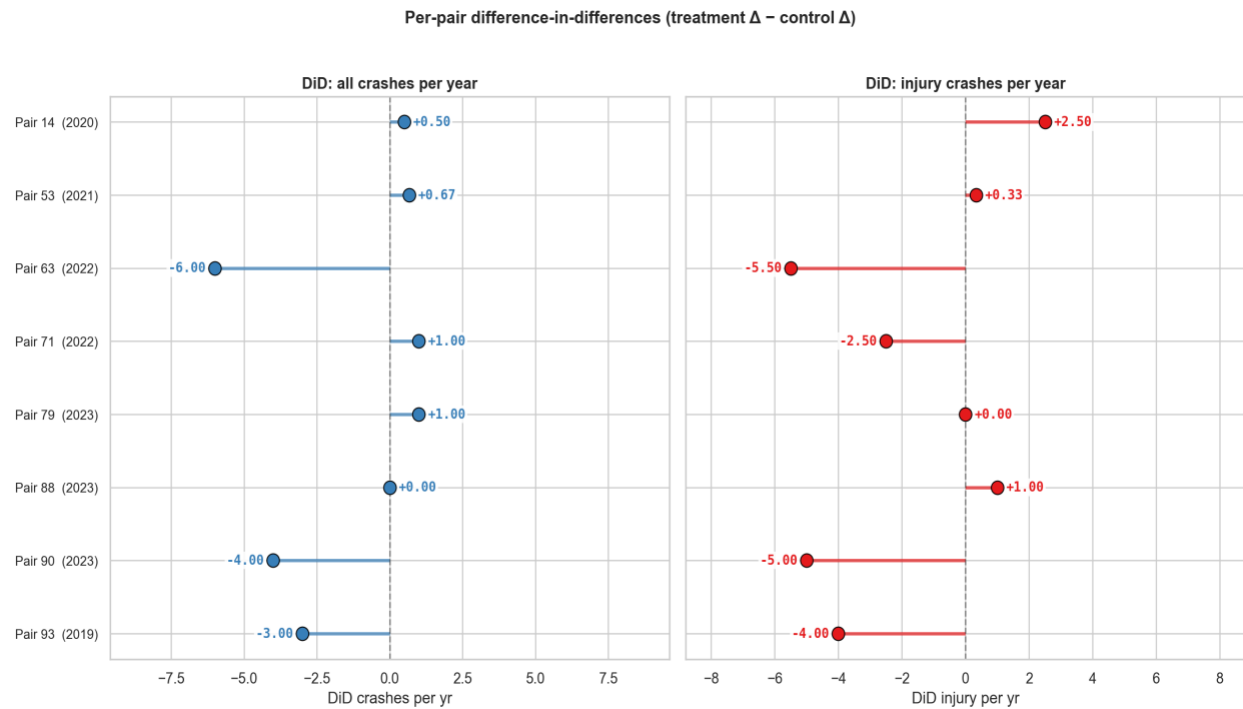


Figure 43: Plots. Forest plot of per pair DiD in yearly crash rates. Left panel: total crashes per year. Right panel: injury crashes per year.

Crash-type shifts

The aggregated severity distribution across the eight treatment sites rotated downward post-installation, consistent with the geometric substitution mechanism described in the published RCUT literature. Although total crash volume held roughly flat, post installation crashes were concentrated in lower severity KABCO categories. The manner-of-collision shifted from angle conflicts at the main intersection toward rear-end events at the U-turn crossover. As seen in **Table 31**, suspected serious injuries “A” fell by 70%, minor visible injuries “B” by 58%, and possible injuries “C” by 50%. Non-injury crashes “O” rose by 11%. The important finding is that crashes at post RCUT locations become less severe.

Table 31: Treatment site percent change in yearly crash rate

KABCO	Description	Pre	Post	% Change
K	Fatality	2	2	no change
A	Suspected serious injury	10	3	-70%
B	Minor / visible injury	19	8	-58%
C	Possible injury	22	11	-50%
O	No injury / PDO	45	50	+11%

As seen in **Table 32**, angle crashes, the most severe configuration at a conventional intersection, dropped by approximately two-thirds. Rear-end crashes, however, rose by 81%. This is the geometric mechanism the FHWA RCUT guidance describes: the RCUT eliminates left-turn-across-traffic angle conflicts at the main intersection and replaces them with merging conflicts at the U-turn crossover, which produce lower severity rear-end events [6]. Pair 71 (Fayetteville) is the cleanest in-sample example of this tradeoff with total crash DiD showing mildly positive (+1.0 per year) while injury crash DiD is clearly negative (-2.5 per year), so a total crash only evaluation would have missed the safety improvement.

Table 32: Manner of crash counts at the eight treatment sites, pre vs post installation, aggregated across the symmetric per-pair windows.

Manner of crash	Pre	Post	% Change
Angle (high severity, T-bone)	58	19	-67%
Rear-end (lower severity, U-turn crossover merge)	16	29	+81%
Sideswipe	6	4	-33%
Head on / Other	19	22	+16%

Consistency with the published RCUT literature

The FHWA Restricted Crossing U-turn Informational Guide and the NCDOT RP 2020 47 Superstreet evaluation report injury crash reductions in the 40 to 60% range at converted intersections. Total crash counts are noisier as RCUT conversion can trade through lane angle conflicts for rear end and sideswipe conflicts at the U-turn crossover, which do not typically produce significant injuries. The Georgia crash pattern is consistent with that mechanism, which is that RCUT treatment sites shed injury crashes faster than they shed total crashes, and in some cases total crashes are flat or up while injury crashes still fall.

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