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WHITE PAPER

How Much Is Enough? Parking Usage in New Jersey Rental Units: Results from a Survey of Developers, Owners and Managers

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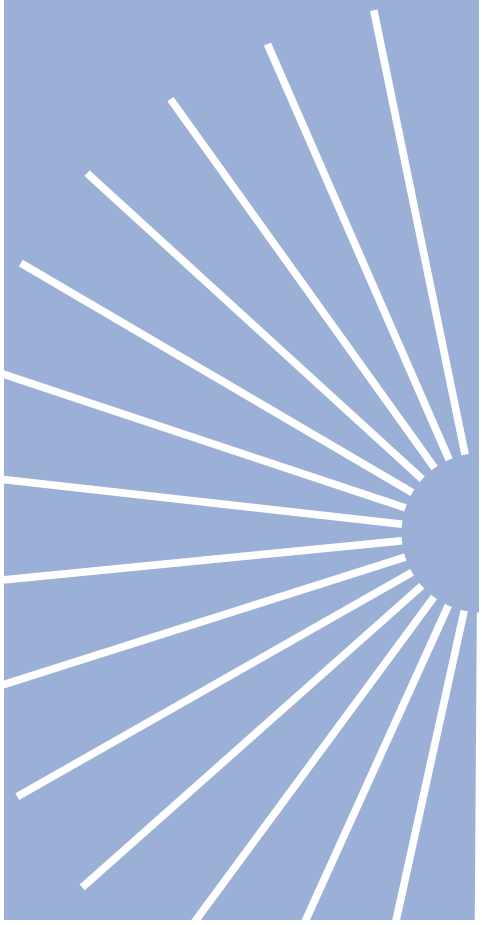

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Executive Summary

Parking requirements for new developments continue to gain substantial nationwide attention for a variety of reasons. One of the seminal underwriting evaluations that must be conducted for all residential developments is a comprehensive understanding of parking requirements and the associated necessary design. The type of parking (i.e. surface, structured, underground) and the quantity of parking spaces have a direct impact on the initial construction costs as well as on the ongoing operating expenses which, in turn, affect the required rents and the overall financial viability of a project. Therefore, any reduction in mandated parking requirements for residential developments will lower initial construction costs and decrease ongoing operating costs which will effectively allow for the reduction of rents, thereby reducing the end user's cost of living and providing an opportunity to address larger housing affordability issues.[1] Moreover, the environmental impact of parking surfaces is a growing concern, as parking contributes to urban heat islands and altered stormwater runoff, both of which exacerbate climate challenges.[2] Indoor parking, often constructed with concrete, is a significant source of carbon dioxide emissions, with up to 12 percent of New Jersey's emissions attributed to the concrete industry.[3] Additionally, with the rise of ride-sharing services and transit-oriented development, the mandate for excessive and unnecessary parking must be re-evaluated as the end user may not actually need and utilize all the parking that would otherwise be provided. In response to all these factors -- affordability goals, environmental sustainability, and evolving transportation trends -- numerous municipalities across the country are rethinking the appropriate amount of parking, and are proactively implementing the reduction and, in some instances, even the elimination of minimum parking requirements.

The Rutgers Center For Real Estate (RCRE) prepared this paper documenting that renter-occupied households own fewer cars per unit than developers are required to provide as stipulated by the Residential Site Improvement Standards (RSIS) in New Jersey.[4] To reach this conclusion, parking ratios have been computed from three (3) data sources: the Rutgers Parking Survey, a more detailed subset of the Rutgers Parking Survey, and the 2021 5-Year American Community Survey (ACS). By having access to granular parking data, it is possible to assess whether parking used by renters aligns with RSIS requirements and whether any adjustments are necessary to RSIS requirements in order to optimize and accommodate changing transportation trends and preferences. In Table 1 below, the proposed new standards for parking ratios are presented in the columns marked "RCRE". In these columns, the parking ratios that are reported are the simple average of estimated parking ratios from the three (3) data sources.

[1] Litman (2023) estimates that one parking space per unit increases moderate-priced housing costs by around 12%, and two spaces raise lower-priced housing costs by 25%. Gabbe and Pierce (2017) find that the cost of garage parking for renters is approximately $1,700 per year, and the bundling of a garage space adds about 17% to a unit's rent.
[2] See https://coast.noaa.gov/digitalcoast/stories/californiawater.html for an example study.
[3] See https://psci.princeton.edu/tips/2020/11/3/cement-and-concrete-the-environmental-impact
[4] See https://www.nj.gov/dca/divisions/codes/codreg/pdf_regs/njac_5_21.pdf Section 5:21-4.14

Table 1: Comparison of Parking Ratios

Bedrooms	Garden			Highrise		
	RCRE	RSIS	Difference	**RCRE**	RSIS	Difference
Studio + 1	**0.98**	1.8	0.82	**0.56**	0.80	0.24
2	**1.45**	2	0.55	**1.40**	1.30	-0.10
+3	**1.80**	2.1	0.30	**1.09**	1.90	0.82
Average	**1.41**	1.97	0.56	**1.01**	1.33	0.32

Note: The column differences show the difference between the RSIS Parking ratios and the average of the three data sources

The results are grouped by product type: "Garden" for Low-Rise and Mid-Rise buildings and "Highrise" for high-rise buildings to make it comparable with the RSIS ratios.[5] **Focusing on Garden apartments, the RCRE estimates for Garden apartment communities are, on average, 0.56 cars per unit lower than the RSIS requirements.** The difference between the RCRE estimates and RSIS requirements varies by unit type, with a discrepancy of 0.82 for Studio and 1-Bedroom units, 0.55 for 2-Bedroom units, and 0.30 for +3-Bedroom units. In considering a hypothetical Garden apartment community of 145 units, the results of this study imply that RSIS over-requires parking for this community by 102 parking spaces.

For Highrise apartment communities, the RCRE estimates imply that RSIS over-provides for parking by 0.32 units per average, with an overprovision of 0.24 cars per unit for Studio and 1-Bedroom units, a slight under provision of -0.10 for 2-Bedroom units and a notable overprovision of 0.82 for +3-Bedroom units. For a hypothetical Highrise apartment community consisting of 400 units, the results of this study imply that RSIS over-requires parking for this community by 75 parking spaces.

Practically speaking, to the extent that higher construction costs must be accompanied by higher rents, the RSIS over-stipulation of required parking dramatically reduces the affordability of rental housing. If each parking space costs an average of $27,900 to build,[6] and assuming RSIS over-requires parking by approximately 0.5 cars per unit on average, then the RSIS over-requirement of parking increases construction costs by approximately $13,950 per unit for every unit built. Another way of stating the same observation, is that a development project that overbuilds 100 parking spaces results in an additional $2,790,000 cost that, instead of being used to fund other improvements, is borne solely by the end-user.

Further, to the extent that rents must cover construction costs, the RSIS over-requirement of parking increases rents paid by renters in New Jersey by approximately $80 per month per unit (relative to a parking requirement that is more in line with the estimates presented in this study).[7] Average rents in New Jersey for units built after 2010 are approximately $2,200 per month.[8] If

[5] The Garden Apartment requirements from RSIS are for buildings with fewer than ten stories, applicable to Low-Rise and Mid-Rise development, and RSIS Highrise requirements apply to buildings with ten or more stories. See https://www.state.nj.us/dca/divisions/codes/codreg/pdf_regs/njac_5_21.pdf for details.

[6] As documented by WGI Engineering Firm's "Parking Structure Cost Outlook for 2022".

[7] A cap rate on costs of about 7 percent has been applied.

[8] Based on the 2021 5-Year American Community Survey (ACS).

RSIS were to reduce parking requirements by about 0.5 cars per unit on average, such that new parking requirements were in line with the parking data as concluded by this study, then average rents in New Jersey should be expected to fall by nearly 4% per unit, all else held equal.

Survey Design and Data

This section presents the three data sources used in the analysis section, presenting their main characteristics and sample size.

1- Rutgers Parking Survey

The survey consists of a 2-page, 19-question survey designed to be answered by multifamily rental developers, owners and property managers to understand how features of a property, tenants, and the surrounding community interact to generate parking demand. A copy of this survey is shown in Appendix A. The goal of the survey was to be concise and straightforward to complete and include questions relevant to parking demand and supply. With respect to parking demand, the survey included questions on locational attributes (easy availability to mass transit, mixed-use, essential retail), product type (i.e., townhome, low-rise, etc.), bedroom mix, rent, and income. With respect to parking supply, the survey requested information about parking spaces provided and utilized, type of parking (i.e., surface lot, private garage, etc.), monthly fees, and a few other questions.

The survey was distributed to multifamily rental developers, owners and property managers who coordinated with individual property managers to complete the specific property information. All responses were kept confidential. The collected information was then entered into a data software program called Stata in order to perform the statistical analysis. A total of 239 surveys (one for each property/community) from 47 development companies was received, accounting for more than 38,000 units. Thirteen (13) surveys were dropped from the data set due to incomplete information on the distribution of bedrooms and 35 surveys were eliminated due to missing data related to the number of off-street parking spaces (question B.12), or the number of off-street parking spaces utilized (B.13). Then 16 surveys were dropped that were Townhomes or did not have a classification of development type (A.3). The remaining data set, the "estimation sample," includes information on 175 properties and accounts for 28,040 market-rate units and 888 affordable units. Given the limited information received regarding affordable housing units, the analysis consolidates the affordable units with the market units.

Table 2 shows some details of the estimation sample by county. Columns (2) and (3) show the estimation sample's properties and unit count. In eleven (11) counties, the survey includes at least six (6) different properties/communities and covers at least 450 rental units. Columns (4) and (5) show properties and unit count for newer properties built after 2000. These columns show that about 2/3rds of the units in the estimation sample were constructed after 2000. Columns (6) and (7) include estimates based on data from the 2017-2021 ACS on renting households in New Jersey that do not live in group quarters and reside in a structure containing at least two units. Column (6) includes the total number of these households in each county, and column (7) shows households residing in units built after 2000. Finally, columns (8) and (9) report approximate coverage ratios for the resulting sample. Column (8) is computed as the total units built in any year of the estimation sample (column 3) divided by total households as estimated from ACS data (column 6). For column (9), total units built on or after 2000 are computed in the estimation sample (column 5) divided by total households living in units constructed on or after 2000, as estimated from the ACS (column 7). The estimate of coverage ratios will be biased downward because it implicitly assumed that in the denominator of the calculation, one household lives in one unit. That said, the

sample used is appropriately large: As shown in the bottom row of columns (8) and (9), the estimation sample covers approximately 3.2 percent of all rental units and 14.4 percent of all units built after 2000.

Table 2: Comparison of Rutgers Parking Study Estimation Sample to the 2017-2021 ACS

	From Parking Survey				From 2017-2021 ACS*		Parking Survey Coverage	
	All Properties		Built 2000 or Later		All	households in units	All	Units
County	Properties	Units	Properties	Units	households	built >=2000	Properties	Built >=2000
Atlantic	.	.	.	.	.	.		
Bergen	27	4,096	13	2,205	100,196	12,636	4.1%	17.5%
Burlington	9	978	5	493	26,754	4,637	3.7%	10.6%
Camden	5	1,283	3	352	47,593	5,674	2.7%	6.2%
Cape May	.	.	.	.	.	.		
Cumberland	.	.	.	.	.	.		
Essex	34	2,590	17	1,573	147,969	18,571	1.8%	8.5%
Gloucester	1	315	1	315	14,396	2,746	2.2%	11.5%
Hudson	32	8,114	31	7,636	181,317	36,643	4.5%	20.8%
Hunterdon	1	60	1	60	5,076	1,025	1.2%	5.9%
Mercer	7	1,916	3	733	34,950	5,506	5.5%	13.3%
Middlesex	16	3,453	12	1,902	87,338	14,003	4.0%	13.6%
Monmouth	6	900	3	738	43,545	7,558	2.1%	9.8%
Morris	20	3,008	11	1,736	38,331	6,234	7.8%	27.8%
Ocean	.	.	.	.	.	.	.	.
Passaic	3	302	3	302	74,411	5,121	0.4%	5.9%
Salem	.	.	.	.	.	.		
Somerset	2	118	1	58	22,064	5,123	0.5%	1.1%
Sussex	.	.	.	.	4,545	587		
Union	11	1,735	9	1,639	71,849	10,141	2.4%	16.2%
Warren	1	60	0	0	7,395	687	0.8%	0.0%
Total	175	28,928	113	19,742	907,729	136,892	3.2%	14.4%

*Sample from the ACS includes only renting households, not living in group quarters, and residing in a structure containing at least two units.

For the purposes of this analysis, parking ratio is defined as follows: the number of off-street parking spaces utilized (from question B.13) divided by the total number of occupied units, computed based on the middle column of question A.8. In the estimation sample of 175 properties, the median overall parking ratio is 1.14 and the average is 1.16.

2- Detailed Rutgers Parking Survey

The parking management practices of developers, owners and property managers vary significantly, with most of them tracking only the total number of cars or parking spaces used at a property. However, a minority of developers, owners and property managers take a more detailed approach by keeping track of the cars associated with each unit. For properties associated with this forward-thinking group, it becomes possible to develop precise estimates of vehicles per unit for each bedroom type, allowing for a more accurate comparison with the RSIS requirements.

To shed light on the significance of such detailed information, a summary of parking data from twelve (12) Mid-Rise developments and five (5) Low-Rise developments is presented in Table 3 below.[9] These developments correspond to Garden Apartments according to the RSIS definition. Each parking ratio reported in the table is computed as a weighted average, where the weight for a particular parking ratio is determined by the number of units in that specific development relative to the total number of units across all the developments considered.

Table 3: Parking Information for properties in the Detailed Rutgers Parking Survey

Bedrooms	Low-Rise			Mid-Rise		
	Occ. Units	Unit w/ data	Parking Ratio	Occ. Units	Unit w/ data	Parking Ratio
Studio	14	12	1.08	225	183	1.1
1	468	287	1.38	1342	1023	1.26
2	657	351	1.7	1293	1178	1.45
3+	94	84	1.95	244	218	1.73

The data indicates that the parking ratios generally fall within the range of 1.08 to 1.95 for both Low- Rise and Mid-Rise developments, depending on the bedroom type. These ratios are derived from the detailed information on cars associated with each unit, providing a more accurate representation of parking demand within these properties.

3- 2021 5-Year American Community Survey (ACS)

The third data source is the 2021 5-Year American Community Survey (ACS), collected by the U.S. Census Bureau. Each year, the ACS randomly samples households in the United States and asks questions about demographics, income, housing, and other variables. The ACS microdata, which contains detailed individual-level information, is made freely available to researchers, allowing for in-depth analysis and exploration of diverse topics.[10] Leveraging this rich dataset, the investigation is centered on renting households residing in New Jersey and living in housing structures comprising at least two housing units. As this study specifically targets multifamily rental housing units, single-family detached or attached homes have been excluded from the sample set to ensure the relevance and applicability of the findings in this study.

[9] Unfortunately, this level of detail for any high-rise developments is unavailable in this data source.
[10] The ACS data are available for download at https://usa.ipums.org/usa/

The sample set has been limited to renter-occupied households living in New Jersey and living in a housing structure containing at least two housing units. In total, this study's ACS estimation sample set consists of 35,723 respondents, representing the experiences and characteristics of a significant number of the 907,729 multifamily rental housing units in New Jersey. This sizable sample size provides a robust and comprehensive understanding of the rental housing landscape in the state, complementing the findings from the Rutgers Parking Survey data to draw conclusions and inform policy recommendations. Appendix B discusses how ACS microdata is used to create parking statistics.

Analysis

In this paper, different methods have been used to analyze each data set, depending on the characteristics of each data source. In the case of the Rutgers Parking Survey, in the survey responses received, developers, owners and property managers list the total number of parking spaces used and the total number of occupied units by number of bedrooms (Studio, 1-Bedroom, 2-Bedroom, and +3-Bedroom). Given this feature, a "regression analysis" has been used to determine the parking ratios in these data. Appendix C explains how regression analysis works in this context.

To compare the estimated parking resulting from the survey to the requirements of RSIS, it is assumed that Low-Rise and Mid-Rise developments are subject to the RSIS requirements for "Garden Apartments," and High-Rise developments are subject to the RSIS requirements for "High Rise". These assumptions are based on information in Table 5.1 of the RSIS that defines low-rise and mid-rise as "up to nine stories" and high rise as "10 or more stories**.** Then, for each type of development, the average of the parking ratios for each type of unit from the three data sources has been taken to conclude the proposed parking ratios.

Table 4 presents the estimated parking ratios for the three data sources, as well as the average of them (the "RCRE" estimate) and compares it with the RSIS requirements for Garden Apartments.

Table 4: Garden Apartments - Parking Ratios Comparison

Bedrooms	Rutgers Parking Survey	Detailed Rutgers Parking Survey	ACS data	**RCRE** (Average)	**RSIS**	**Difference** (RSIS - RCRE)
Studio + 1	0.79	1.27	0.88	**0.98**	**1.8**	**0.82**
2	1.7	1.5	1.14	**1.45**	**2.0**	**0.55**
+3	2.32	1.77	1.32	**1.80**	**2.1**	**0.30**
Overall Average	1.60	1.51	1.11	**1.41**	**1.97**	**0.56**

The RCRE estimates of parking ratios significantly deviate from the RSIS standards, regardless of the unit type. Specifically, for Studio and 1-Bedroom units, the analysis indicates a parking ratio of 0.98 per unit contrasting with the RSIS requirement of 1.8. Similarly, for 2-Bedroom units, the analysis indicates a parking ratio of 1.45 per unit contrasting with the RSIS requirement of 2.0. Further, for +3-Bedroom units, the analysis indicates a parking ratio of 1.80 per unit contrasting with the RSIS requirement of 2.1 In summary, the overall average for all unit types in Garden Apartments is 1.41 while the RSIS average is 1.97 a difference of 0.56.

To grasp the real-world implications of the gap between RSIS mandates and the RCRE estimates for Garden Developments, consider a hypothetical development of 145 units. Assuming a unit mix composition that is consistent with the data obtained from the responses to this survey, this hypothetical development contains 84 (58%) Studio and 1-Bedroom apartments, 56 (39%) 2-Bedroom apartments, and 5 (3%) +3-Bedroom apartments.

Table 5: Example 1- Representative "Garden" Development

Bedrooms	# Units	RCRE	Required Parking	RSIS	Required Parking	Delta
Studio + 1	84	0.98	82	1.8	151	**69**
2	56	1.45	81	2	112	**31**
+3	5	1.8	9	2.1	11	**2**
Total Parking	**145**		**172**		**274**	**102**

Utilizing the RCRE parking ratios, the project would require a total of 172 parking spaces. In this hypothetical scenario, the RSIS guidelines call for an additional 102 parking spaces beyond what the analysis suggests is necessary. This discrepancy results in an overabundance of parking resources by a substantial margin, representing a significant 59% surplus.[11] Additionally, employing the estimated cost of $27,900 per parking space leads RSIS to increasing construction costs over what is required for expected parking of approximately about $2.845 million, a cost that likely winds up borne by the end-user in the form of increased rent.

Table 6 presents the estimated parking rations for two data sources (there were no Highrise communities in the Detailed Rutgers Parking Survey), as well as the average of them and compares it with the RSIS requirements for Highrise apartments.

[11] Overprovision=$100\left(\frac{102}{172}\right) = 59\%$

Table 6: Highrise Apartments – Parking Ratios Comparison

Bedrooms	Rutgers Parking Survey	ACS data	**RCRE** (Average)	**RSIS**	**Difference** (RSIS-RCRE)
Studio + 1	0.51	0.61	**0.56**	**0.80**	**0.24**
2	1.73	1.06	**1.40**	**1.30**	**-0.10**
+3	0.99	1.18	**1.09**	**1.90**	**0.82**
Average	1.08	0.95	**1.01**	**1.33**	**0.32**

Similar to the Garden Apartments Parking Ratio Comparison as shown in Table 4, the average Parking Ratios for Highrise apartments also deviate from the RSIS standards to a significant degree. Specifically, for "Studio and 1-Bedroom" units, the analysis indicates a parking ratio of 0.56 per unit contrasting with the RSIS requirement of 0.80. Similarly, for 2-Bedroom units, the analysis indicates a parking ratio of 1.4 per unit contrasting with the RSIS requirement of 1.3 per unit. Further, for +3-Bedroom units, the analysis indicates a parking ratio of 1.09 per unit contrasting with the RSIS requirement of 1.90 per unit. Such a dramatic overestimating of 0.82 underscores the potential for substantial adjustments in parking allocation for larger units, although the total impact of a change in required parking for +3-Bedroom units will be relatively small since these units typically account for a small percentage of all units in a development. In summary, the RCRE estimate for all unit types in Highrise apartments is 1.01 while the RSIS average is 1.33, a difference of 0.32.

Applying the parking ratios for a hypothetical Highrise Development with 400 units, where 68% (272) are "Studio and 1-Bedroom units, 26% (104) are 2-Bedroom units, and 6% (24) are +3-Bedroom units, RSIS requirements result in 75 more parking spaces than required by the results of this analysis, representing an overestimation of 23%.[12] Using the estimated cost of $27,900 per parking space, this adds approximately $2.1 million in additional project cost to this hypothetical development.

Table 7: Example 2- Representative Highrise Development

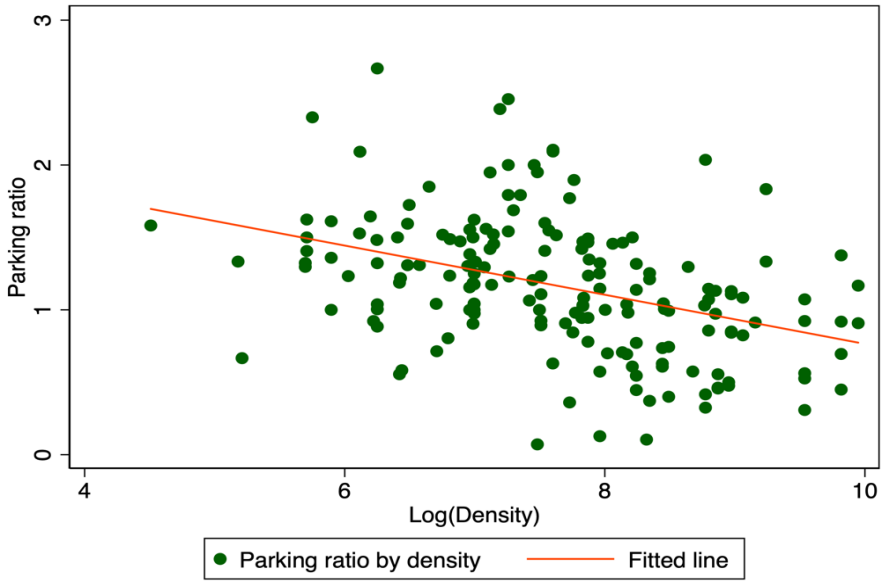
Bedrooms	# Units	RCRE	Required Parking	RSIS	Required Parking	Delta
Studio + 1	272	0.56	152	0.8	218	**66**
2	104	1.40	146	1.3	135	**-11**
+3	24	1.09	26	1.9	46	**20**
Total Parking	**400**		**324**		**399**	**75**

[12] Overprovision=$100\left(\frac{75}{324}\right) = 23\%$

Other Considerations

It should be noted that even though RSIS considers product type (Garden vs Highrise) and bedroom distribution, it omits many factors that may also influence parking. As part of this study, the correlation between population density and the average parking requirement based on zip codes was also reviewed. This relationship is shown in Figure 1, which shows how zip codes characterized by higher population densities (x-axis) exhibit a correspondingly reduced parking ratio (y-axis).

Figure I: Parking ratios by population density.



Source: Own calculation based on Rutgers Parking Survey and data from Simple Maps.[13]

This relationship is not surprising as urban areas with elevated population densities often enjoy well-developed public transportation infrastructure, increased access to amenities and services, and a greater prevalence of alternative transportation modes like walking, biking, and ride-sharing services. This comprehensive network of transportation options leads to a diminished reliance on personal vehicle utilization, and, as a result, the need for extensive parking facilities diminishes.

Thus, even though in Table 1 specific recommendations are made to reform RSIS parking requirements, policymakers should be encouraged to consider allowing for reduced parking ratios in higher-density areas.

[13] See https://simplemaps.com/data/us-zips

Appendix A: Rutgers Parking Survey Questionnaire

A. Questions on Building Characteristics

1. Name of Community and Street and City Address _____

_____

2. Development type (check any that apply):
   - TOD (less than 0.5 miles away from transit stop) Y/ N
     - If yes, what type of transit?

Bus Train Light Rail Other (describe)

   - Mixed Use (at least two uses)
     - If yes, what type of uses?

Restaurant Retail Office Medical

3. Product type:
   - Townhome (A multilevel unit with interior stairs but not a loft)
   - Lowrise 1-3 stories
   - Midrise 4-9 stories
   - Highrise 10 or more stories

4. When was the Year Built/Completed _____

5. Is the community a condominium or a rental? _____

6. Current Occupancy Rate _____

7. Market rate rents: Base rent range (net of any other fees or concessions, if applicable); *Skip if this is a condominium community.*

Monthly Base Rent Range
Studio _____
1BD _____
2BD _____
3BD _____
4BD _____

8. Unit Mix and Population: Total units and population (according to lease documents)

	Total Vacant Units	Total Occupied Units	Total Residents
Studio	_____	_____	_____
1BD market	_____	_____	_____
1BD affordable	_____	_____	_____
2BD market	_____	_____	_____
2BD affordable	_____	_____	_____
3BD market	_____	_____	_____
3BD affordable	_____	_____	_____
Total (sum rows)	_____	_____	_____

9. Are there essential uses located less than 0.5 miles away? Y / N
    - If yes, what type of uses?

Grocer/Convenience Store Pharmacy Medical Office Bank Other (describe)

10. What is the average household income per unit? (market rate units only)

11. Can you estimate the percent of households earning the following (totals should sum to 100%)

    - Less than $50K per year
    - Between $50K - $100K per year
    - Between $100K - $150K per year
    - Between $150K - $200K per year
    - Between $200K - $250K per year
    - More than $250K per year

B. Questions on Parking

12. Total number of off-street parking spaces provided

13. Total number of off-street parking spaces utilized

14. Is parking assigned? Y / N

15. Type of Parking

    - Surface lot Y / N
    - Podium or Structured Parking garage Y / N
    - Private garage Y / N
        - # of private garages

16. Is there a fee for parking Y / N
    - If yes, what is the monthly fee?

17. Is parking shared with other uses Y / N

    - If shared, with what other uses?

Retail Restaurant Office Other (describe)

18. Does your community provide electronic vehicle (EV) charging stations? Y / N

    - If yes, how many?

19. Does your community offer shuttle to transit?Y/N

Appendix B: The 2021 5-Year ACS

The American Community Survey (ACS) is a representative survey of households that the U.S. Census Bureau administers. Starting in 2000, the ACS replaced the long form of the Decennial Census, and since then has been conducted every year, with 2021 being the most recent year available. The survey asks questions about the household and individual people in the household. For the purposes of the analysis in this paper, household-level variables are used and from the combined ACS data from 2017-2021, the "2021 5-year ACS data."

In the 2021 5-year ACS data, 160,860 survey respondents account for 3.397 million households in New Jersey.[14] Once the sample set is restricted to include only renter-occupied households that rent and do not live in single family housing (attached or detached), the number of survey respondents drops to 46,246, accounting for 1.230 million households. Finally, after excluding households that rent detached or attached single-family homes and that were in the counties that are represented in the Rutgers Parking Survey, the number of survey respondents falls to 35,723, accounting for 907,729 households.

ACS data from IPUMS USA was downloaded. This data is freely available to the public and is available at https://usa.ipums.org/usa/index.shtml. The ACS collects many data from each household in the survey, but this analysis focuses on four specific questions:

- BEDROOMS, the number of bedrooms in the unit. This ranges from "no bedrooms" (Studio) to 6 bedrooms. There are very few rental units in multifamily buildings with more than three bedrooms, so all units with three or more bedrooms have been combined in the +3-Bedroom category.
- BUILTYR2, the decade in which the unit was built.
- HHINCOME, annual household income. The IPUMS USA website states this is the "total money income of all household members age 15+ during the previous year."
- HHWT estimates the number of households a given survey respondent represents.
- UNITSSTR, the number of housing units in the structure. According to the IPUMS USA website, this variable "reports the number of housing units (both occupied and vacant) in the structure containing the household. The count does not include store and office space in the same building."
- VECHICLES, described on the IPUMS website as "the number of cars, vans, and trucks of one-ton capacity or less kept at home for use by household members." Note that the IPUMS codes for VEHICLES range from 1 through 6 (1 for one car, 2 for two cars, and so forth) and 9, which is the code for "No vehicles available." All 9 codes have been treated as if the household has 0 cars.

To show how the average cars per household using IPUMS data was computed, the calculation is as follows:

Numerator:	sum over survey responses of [vehicles * hhwt]
Denominator:	sum over survey responses of [hhwt]
and cars / household	= numerator / denominator

[14] This excludes a small number of households that live in "group quarters."

Appendix C: A Regression Primer

To understand how regression works, consider the following straightforward example. Suppose there is data from three hypothetical parking surveys labeled A, B, and C – ignore rows D and E for now – shown in Table 8 below:

Table 8: Hypothetical Regression Example:

Development	Total Cars at Development	1 BR units	2 BR units
A	150	50	50
B	151	51	50
C	152	50	51
D	151	50	51
E	1522	50	51

A and B have the same number of 2-Bedroom units, so the change in total parking from A to B identifies how an additional 1-Bedroom team affects total cars. A and C have the same number of 1-Bedroom units, so the change in total parking from A to C identifies how an additional 2-Bedroom unit affects total cars. Therefore, with just data from A, B, and C, a basic regression analysis would identify that each additional 1-Bedroom unit is associated with one extra car (A to B) and each additional 2-Bedroom unit is associated with two extra cars (A to C).

Now consider adding parking survey D to the sample (but not E). Once D is added to the sample, the regression can no longer perfectly fit the data. A comparison of A to C suggests adding one 2-Bedroom increases parking by two cars but comparing A to D suggests adding one 2-Bedroom increases parking by one car. Once D is added to the sample, there is no perfect way to best fit the data. A regression framework is just an algorithm that specifies how to minimize model errors – and there will be errors since one model will not be able to fit both C and D simultaneously.

The typical regression framework, Ordinary Least Squares or "OLS," minimizes the sum of squared model errors. This is typical because the formula that accomplishes this minimization can be derived with pencil and paper and quickly implemented, which was important back when computing power was lacking. When the data consist of survey A-D, OLS will report that each extra 2-Bedroom unit is associated with 1.5 extra cars. If x is defined as the model-predicted cars per 2-Bedroom, then (summarizing) OLS will find x to minimize the sum of squared model errors from C and D, which will be $(2 - x)^2 + (1 - x)^2$ and the value of x that minimizes this expression is x = 1.5.

Since OLS minimizes the sum of squared errors, outliers in the data can influence regression estimates. To see this, imagine adding survey E, so the new sample includes all surveys A-E. Survey E reports 1,522 cars. Perhaps that is accurate, but likely not. One guess is that the actual number from E is 152, and during the input process, an inadvertent error occurred when an individual inadvertently pressed the number '2' key twice. But if no one catches this mistake – and more subtle errors are difficult if not impossible to detect – then the OLS estimate that includes all surveys A-E will state that each additional 2-Bedroom unit adds another 458 cars: The value x =

458 minimizes the sum of squares $= (2-x)^2 + (1-x)^2 + (1372-x)^2$. This expression is the sum of squared model errors once E is included in the sample.[15]

A different estimator, which has been used for this analysis, is a median regression. The median regression minimizes the sum of the absolute value of the model errors, reducing the impact of outliers on estimates relative to estimates generated by OLS. If x is defined as the estimate, the median regression finds x to minimize $|2-x| + |1-x| + |1372-x|$. For the data inclusive of observation E, x = 2.0 is the value that would be returned in a median regression. In other words, even with E in the sample, the estimate from median regression would be that an additional 2-Bedroom unit adds 2 more cars.

Finally, it should be noted that in practice, by applying "sampling weights," researchers can use quite a bit of discretion in determining how a model should fit data, even when sticking to one particular estimator (for example, sticking to OLS). A sampling weight essentially acts as if multiple copies of a survey exist. Let us once again consider only surveys A-D. If a researcher wanted to match the data more closely in survey C as compared to survey D, the researcher could assign a sampling weight of (say) 10 to C and 1 to D. This is like pretending the sample includes 10 surveys exactly like C but only one survey exactly like D. Once these sampling weights are applied, the OLS estimate finds x to minimize the equation $10 * (2 - x)^2 2 + 1 * (1 - x)^2$, where 10 is the sampling weight for C and 1 is the sampling weight for D. Note that x = 1.91 minimizes this expression. As the sampling weight on C increases relative to the sampling weight on D, the OLS estimate moves closer and closer to 2. For example, by setting the sampling weight on C to 50 and the weight on D to 1, the estimate x = 1.98 minimizes the expression $50 * (2 - x)2 + 1 * (1 - x)2$. Conversely, as the sampling weight on D increases relative to the sampling weight on C, the OLS estimate moves closer and closer to 1.

[15] Note that 1372 = 1522 – 150. To be clear, by adding data point E an example is constructed where the model does not fit the data due to an error in data entry. Simple models do not fit the data perfectly for many reasons. The single most important reason that simple models do not fit data are that the models are simple by design, such that they capture important trends in the data but not every detail. This is the spirit of adding data point D.