Demand Volatility, Adjustment Costs, and Productivity: An Examination of Capacity Utilization in Hotels and Airlines

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A Additional Control Variables

The list of metro area (destination)-year level information includes: personal income, personal income per capita, the average wage in the leisure and hospitality sector (for hotel application only), the unemployment rate, the passenger facility charge (for airline application only), the number of employees in the leisure and hospitality sector (for hotel application only), the number of employees in the non-farm sector (for airline application only), the (primary) statewide average commercial price of electricity, the number of employees in the leisure and hospitality sector per square mile (for hotel application only), the share of non-farm employees in the leisure and hospitality sector (for hotel application only), and the U.S. Department of Housing and Urban Development's (HUD) fair market rent for three-bedroom units. These observations were gathered from a variety of sources including the Bureau of Economic Analysis (BEA), the Bureau of Labor Statistics (BLS), the Energy Information Administration (EIA), the State and Metropolitan Area Data Book, and the County and City Data Book.[1] Finally, in order to ensure my results are robust to longer-run trends, I also construct a set of five-year log differences of several of the variables including personal income, personal income per capita, number of employees in the leisure and hospitality sector (for hotel application only), and number of employees in the non-farm sector (for airline application only).

B An Analytical Framework for the Instrumental Variable

In this section, I provide a brief analytical motivation for the instrumental variable approach described in section II.D. The purpose of this section is provide an outline for both the source of the potential simultaneity causality issue, and the motivation for the use of the particular form of the instrument used in the main results.

I assume that demand for market i, segment/airline m, in year t, and month s is given by the following:

$$Q_{imts}(P_{imts}) \quad = \quad Q_{its}\phi_m(P_{imts})$$

where Q_{its} is the aggregate quantity demanded in market i, in year t, and month s, and serves the role as the demand shifter in the residual demand facing the segment/airline m. The price is given by P_{imts}, and I assume that the function $\phi_m(\cdot)$, which summarizes how the price translates to market-shares for each segment/airline, is decreasing in price.

Consistent with the assumptions regarding the constant returns to scale production technology of both hotels and airlines, I assume that they face constant marginal costs, c_{imt}, up to a capacity constraint. To illustrate the possible endogeneity issue, I allow for the possibility that idiosyncratic shocks to the effective available capacity that might result from maintenance of scheduling issues

[1] For a detailed list of all sources and additional variable information see table 8.

surrounding labor may contribute to quantity fluctuations within the year. As was described in the discussion surrounding the measure of capacity utilization, the assumption of constant marginal costs would hold only up to the capacity constraint. For both hotels and airlines, I do not observe that this constraint is binding at the monthly frequency. Given that even at the monthly frequency some aggregation is taking place, however, one can interpret ω_{imts} as the average idiosyncratic shocks to available capacity experienced during that period.

To the extent that these changes in available capacity (ω_{imts}) within the year influence the firms' pricing decisions, they have the possibility of confounding my estimates–at least in so much as interpreting the results as driven by demand fluctuations.[2] I assume that firms set their prices to maximize profits in each period. The firm sets prices to solve the following problem:

$$\max_{P_{imts}} \left[P_{imts} - c_{imt}\right] Q_{imts}(P_{imts})$$

$$\text{s.th. } Q_{imts} \leq K_{imt}\omega_{imts}$$

And, an implicit characterization of the optimal price is given by:

$$\begin{aligned} P^{\star}_{imts} &= c_{imt} + \frac{\phi_m(P^{\star}_{imts})}{\phi'_m(P^{\star}_{imts})} + \lambda_{imts} \\ &\equiv h(Q_{its}, \omega_{imts}). \end{aligned}$$

where λ_{imts} corresponds to the (time-varying) shadow cost of capacity, and $\phi'_m(\cdot)$ corresponds to the first derivative of the function $\phi_m(\cdot)$.

Clearly, to the extent that the available capacity (or implicitly the marginal costs) of the firm changes over the year, and these changes are reflected in prices, it is likely that some of the observed volatility in quantity demanded reflects these changes.[3] Substituting the firm's optimal price into the demand function gives the equilibrium quantity demanded:

$$Q_{imts} = Q_{its}\phi_m(h(Q_{its}, \omega_{imts})).$$

This condition for the equilibrium quantity demanded makes clear the case for the possibility of a simultaneity causality issue. The volatility of quantity demanded at the segment level driven by demand fluctuations might cause changes in the capacity utilization in the face of adjustment costs–the effect I attempt to estimate. However, it is also possible for changes in the available capacity or productivity (captured here through changes in ω_{imts}) to generate changes in the volatility of quantity demanded.

The foundation of the identification strategy outlined in section II.D is also illustrated by this analytical framework. The goal is to isolate the movements in quantity demanded that reflect volatility in demand as opposed to idiosyncratic movements of available capacity or scheduling considerations within the year. Under the form of demand given above, a natural way to isolate these movements is to focus on both the volatility in demand at the aggregate market level, as well as some measure of a particular hotel segment's (airline's) market share. For the latter, in order for idiosyncratic (unobservable) shifts in available capacity at the hotel segment (airline) level not to impact the estimates of this share the instrumental variable approach outlined in section II.D uses the average market shares experienced in all other geographic markets.

A potential drawback of this formulation is it abstracts from any substitution between demand for hotels and airlines to their respective "outside" goods (e.g., vacation rentals by owners, or driving to the destination). Consequently, it would be natural to infer that the overall market size

[2]If the marginal costs, c_{imt}, varied within the year due to say changing factor prices, then the same logic would apply.

[3]This formulation also makes clear why, in the event that all of the variation in demand was reflected in changes in prices (as opposed to quantities) due to capacity constraints, the analysis in section VI.C, which incorporates the variation in prices into the demand volatility measure, would be the most appropriate.

(Q_{its}) is a function of the relative prices of all the inside goods (e.g., an aggregate price index $\overline{P}_{its}$ for all the inside goods) versus the outside good (P^0_{its}) for each of these industries. In the event that the pricing decisions of individual hotels and airlines for flights to a particular destination take this aggregate price index as given, as is commonly assumed in constant elasticity of substitution (CES) demand systems, then while the interpretation of Q_{its} would be affected, its viability as exogenous variation in demand conditions would remain.[4] Given the number of hotels in the metro areas and the number of flights into each destination in my study, it is natural to assume that firms may take the volatility in aggregate demand of the metro area or destination as exogenous.[5]

C Demand Volatility for Hotels and Airlines

In the main results of the paper, demand volatility was measured at the monthly frequency. At this frequency the fluctuations in demand are largely predictable. Demand for hotels and airlines is also likely to exhibit fluctuations at a daily (i.e., day of week) frequency that would also be predictable to firms and managers. While any fluctuations at this higher frequency would likely only further the scope for demand volatility and adjustment costs to lead to differences in capacity utilization (for hotels), these fluctuations are abstracted from in the main results of the paper.

To provide a sense of the size of daily variation in demand for both of these industries, the daily information on room-nights sold across all segments (for hotels) and on the total number of flights (for airlines) were gathered for the same time period used in the main results of paper (see section III).[6] In both cases, the logarithm of quantity was regressed separately for each metro area/destination on a set of year, day-of-week, and month-of-year fixed effects. Figures 1 and 2 display for each metro area/destination the range of both the day-of-week fixed effects (vertical axis) and the month-of-year fixed effects (horizontal axis). Given the logarithm functional form, these ranges can be interpreted as (approximately) peak-to-trough percent differences. For illustrative purposes, the 45-degree line is also displayed in each graph.

For hotels, it is clear that the demand fluctuations at the monthly frequency constitute larger percent deviations than the fluctuations experienced at the daily frequency. Additionally, for hotels a positive correlation between the size of the fluctuations at the daily and monthly frequency appear for the metro areas in my sample. This fact suggests that the role of demand volatility experienced at the daily frequency for hotels is likely to only reinforce the fluctuations occurring at the monthly frequency within the year, given that adjustment costs in capacity are likely to be even more binding at the daily frequency for hotels.

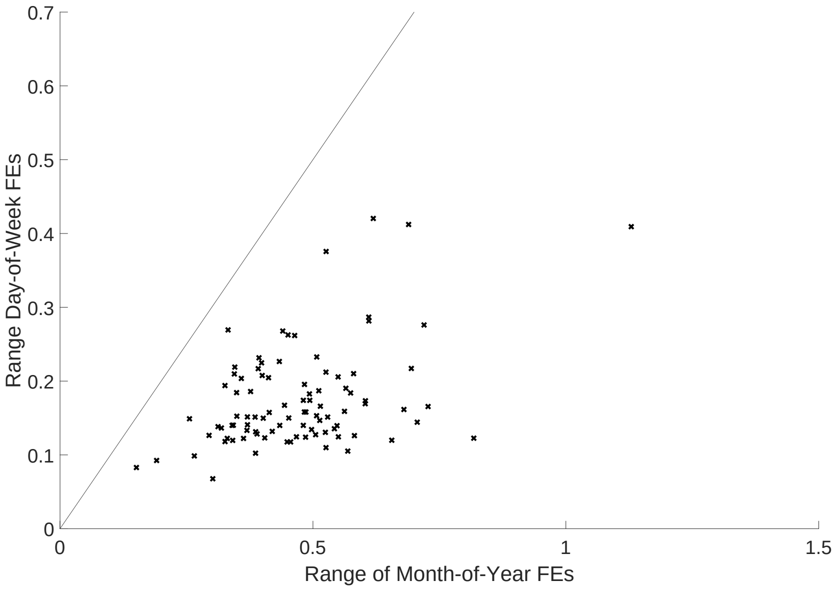
For airlines, the relationship between fluctuations at the daily frequency relative to the monthly frequency across destinations is more mixed. Here, some destinations do experience changes in the number of flights into the airport at the daily frequency that are of a similar or larger relative magnitude to the fluctuations at the monthly frequency. Additionally, the association between the size of the fluctuations as the daily and monthly frequency is weaker compared to hotels.

[4] This reinterpretation would involve relabeling variation in supply conditions that induce variation in the relative aggregate price index of the inside goods to the outside good as "demand volatility." Regarding the likelihood that this sort of consideration is likely to be of empirical importance, the average correlation of the average price and total quantity within the year for the 2,063 metro-segment-year observations for hotels was 0.65 with the interquartile range falling from 0.53 to 0.87. This pattern of the raw correlation between quantities and prices presents strong evidence that the shocks I observe within the year can be attributed to movements in demand as opposed to movements in supply even if one took the view that supply included shifts in the relative price of hotels and the outside option of staying at a hotel.

[5] In section VI.B, I report a set of results for the hotel application using an alternative formulation for the instrumental variable that incorporates the possibility of market-level shifts in supply that could induce aggregate shifts in quantities by incorporating aggregate sales information at the metro area level.

[6] The daily market level information for hotels also came directly from Smith Travel Research, LLC, while the daily information on the number of flights at the market level were gathered using the the On Time Performance data table of the Bureau of Transportation Statistics; see https://www.transtats.bts.gov/Tables.asp?DB_ID=120

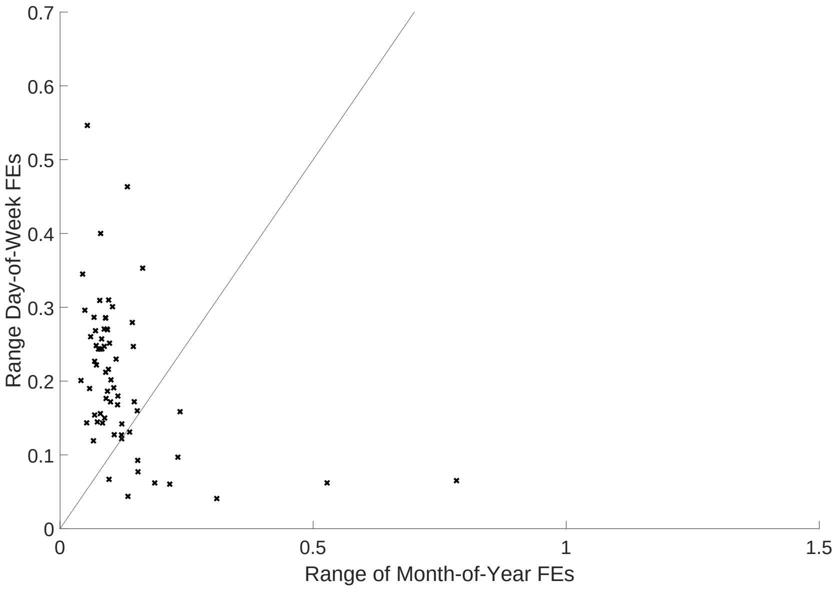
Figure 1: Range of Month-of-Year and Day-of-Week Fixed Effects for Hotel Sample Metro Areas



Source: Smith Travel Research, and author's calculations

This figure displays the scatter plot of standard deviation of the day-of-week and month-of-year fixed effects for all the metro area-year observations in the hotel sample using daily information on the number of room-nights sold for each of the metro area. Section C describes the regression used to estimate these fixed effects, while for a summary of the data see section III. Additionally, the 45-degree line is reported in gray.

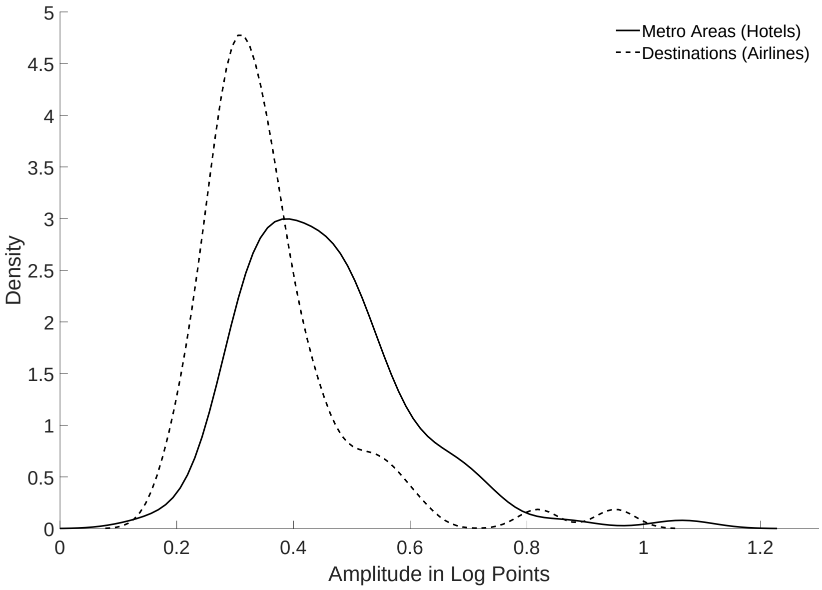
Figure 2: Range of Month-of-Year and Day-of-Week Fixed Effects in Airline Sample Destinations



Source: Bureau of Transportation Statistics, and author's calculations

This figure displays the scatter plot of range of the day-of-week and month-of-year fixed effects for all the destinations in the airline sample using daily information on the number of flights to each destination. Section C describes the explicit regression used to estimate these fixed effects, while for a summary of the data see section III. Additionally, the 45-degree line is reported in gray.

Figure 3: Kernel Density of Monthly Amplitude of Quantity Demanded for Hotel Metro Areas and Airline Destinations



Source: Smith Travel Research, Bureau of Transportation Statistics, and author's calculations

This figure displays the kernel density of the amplitude (peak-to-trough) of the monthly fluctuations in quantity demanded for hotels (room-nights sold) and airlines (passengers) as measured in log points across metro areas (for hotels) and airport destinations (for airlines). These amplitudes were estimated from separate regressions that included a year fixed effects.

Moreover, this analysis also indicates that generally speaking the size of the demand shocks used for the main analysis of the paper–best characterized by the range of the month-of-year fixed effects tend to be slightly larger for hotels relative to airlines. The difficulty in using these last two figures as a basis of comparison for the size of the demand shocks between the two is that for airlines only the number of flights–instead of number of passengers–is observed. Figure 3 reports a more direct comparison of the size of the monthly demand fluctuations used in the main empirical analysis between the two industries. Here, the kernel density of the amplitude (peak-to-trough) of the month-of-year fixed effects are reported (measured in log points), estimated from separate regressions for each metro area (destination) of the logarithm of monthly room-nights sold (passengers) on month-of-year and year fixed effects. On this much more uniform comparison between the two industries, it is clear that the within year fluctuations in demand for hotels across metro areas is a bit larger than for airlines across destinations on average. However, both industries experience a similar range of seasonal fluctuations across metro areas/destinations.

D Returns to Scale

In the main results of the paper, capacity utilization was constructed by assuming constant returns to scale. Several methods exist to estimate the returns to scale of a production function. Two such methods include the panel data approach and the structural approach developed by Olley and Pakes (1996) and extended by Levinsohn and Petrin (2003) and Ackerberg, Caves and Frazer (2015). While the constant returns to scale assumption seems reasonable in the hotel industry, both the panel data and structural approaches provide an opportunity to empirically test the validity of this assumption in the sample. Both methods use orthogonality conditions to estimate input elasticities of the production function.[7] For the Cobb-Douglas production function with an elasticity of substitution between capital and labor of one (see section VI.A), the returns to scale are estimated using the following regression equation[8]:

$$y_{imt} \quad = \quad \beta^0 + \beta^k k_{imt} + \beta \left[r_{it} - w_{it} \right] + \eta_{imt}. \tag{1}$$

Table 1 provides the results for several alternative specifications of the regression given by equation 1 above using the panel data approach. Specifications (a)-(c) report the regression coefficients assuming no technical substitution between capital and labor. Explicitly, specifications (a)-(c), fix $\beta = 0$, and the estimate of β^k corresponds to the returns to scale. Specifications (d)-(f) report the regression coefficients assuming an elasticity of substitution between capital and labor of one. Thus, specifications (d)-(f) allow for an arbitrary output elasticity on labor, while the estimate of β^k still corresponds to the returns to scale (the sum of the elasticities of capital and labor). Within both specifications (a)-(c) and specifications (d)-(f), are varying treatments of fixed effects and the instrument for k_{imt}.

Across all specifications the resulting estimate of β^k remains close to one with a high level of statistical precision.[9] These results provide justification for the constant returns to scale assumption used in the main results.[10]

[7] The effect of demand volatility on factor demand I document offers a justification for the identification result of Bond and Söderbom (2005) of productivity estimates from panel data methods.

[8] Even if a capacity utilization term CU_{imt}, is included in the production function estimating equation 1 via OLS will yield consistent estimates of the scale elasticity as long as the orthogonality condition of capacity and the error term (which will now include the capacity utilization) hold.

[9] It should be noted that the hypothesis of constant to returns to scale can be rejected in favor of an alternative hypothesis of increasing returns to scale. To ensure that the results are not sensitive to an assumption regarding increasing returns to scale, I provide a similar regression table using 1.04 instead of 1 when constructing my measure of capacity utilization; see table 11.

[10] Furthermore, these results also suggest that each of the traditional methods are likely to have their estimates of annual metro-segment productivity be largely driven by the annual occupancy level of a metro area-segment. The data requirements of the structural approach of Olley and Pakes (1996) prohibit this method from being used with the data on hotels. Despite not being able to provide an estimate using this approach, any effect of demand volatility and temporal aggregation present using the panel data method is likely to be present in any application of the more structural approaches. The orthogonality conditions that would identify the coefficient on capital are likely to be similar in both the panel data methods and the structural approaches. As a result, the estimate of β^k is likely to be similar and thus result in similar estimates of productivity for hotels. Furthermore, structural approaches could

Table 1: Regression Results for Estimating the Returns to Scale

	(a)	(b)	(c)	(d)	(e)	(f)
β^k	1.03	1.04	1.04	1.03	1.04	1.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
β				0.00	0.06	0.07
				(0.05)	(0.04)	(0.04)
Dep. Variable Mean	13.60	13.60	13.60	13.60	13.60	13.60
Lag of k_imt instrument			Yes			Yes
Year FEs		Yes	Yes		Yes	Yes
Segment FEs		Yes	Yes		Yes	Yes
Hausman Test			0.00			0.00
Adj. R-squared (1st Stage)			0.99			0.99
Adj. R-squared	0.97	0.98	0.98	0.97	0.98	0.98
Num. Observations	2063	2063	1530	2063	2063	1530

Regression results for several alternative specifications of the regression in equation 1. The estimated coefficient for the returns to scale is reported for all specifications in the first row, with the standard errors clustered at the metro area level reported within parentheses. Additional statistics for each specification are given including the mean of the dependent variable, the p-value for the Hausman endogeneity test (if applicable), the adjusted R^2-statistic of the first stage regression (if applicable), the adjusted R^2-statistic and the number of observations. Specifications (a)-(c) report the regression coefficients assuming no technical substitution between capital and labor. Specifications (d)-(f) report the regression coefficients assuming a Cobb-Douglas form for the value added component of the production function. Specifications within each of the those two forms of the production function include various fixed effects components and instruments for the k_{imt}.

E Cross-sectional Aggregation

Another critical modeling choice I use is the level of cross-sectional aggregation. In the results of the previous section, I measured capacity utilization at the metro area-segment level. This level of aggregation included at minimum four hotels, and on average as many as 43 hotels. A potential concern is, at this level of aggregation, the effect of demand volatility and adjustment costs on capacity utilization does not match the effect when examined at the individual level. Unfortunately, there does not exist individual level information of hotels at the requisite level of disaggregation to replicate the analysis I perform here.

Alternatively, I examine the effect of demand volatility with adjustment costs on capacity utilization with a set of weighted regressions using the number of hotels in each metro area-segment as weights. These weighted regressions should recover the estimate of the coefficient on demand volatility had the underlying individual hotel level data been available.[11]

Table 2 presents the results of the main estimating regression equation 2 for the weighted regressions. Generally speaking, the results from these weighted regressions mirror the results across the main result specifications with only modest declines in the absolute size of the effects across comparable specifications. Here, the evidence suggests that ultimate findings of the paper are probably robust to the level of cross-sectional aggregation.

be problematic in this setup given that they require the unobservable (to the econometrician) to be a scalar. In my setting, not only is the metro area-segment level productivity an unobservable, but the level of demand volatility is an unobservable, causing the scalar assumption to be violated.

[11] Note the standard errors of these regressions, however, will not be reflective of the sampling error had the underlying individual hotel level information been available.

Table 2: Alternative Weighted Regression Results for Hotels

	(a)	(b)	(c)	(d)	(e)	(f)
Demand Volatility	-0.73	-0.36	-0.26	-0.33	-0.20	-0.41
	(0.17)	(0.09)	(0.10)	(0.14)	(0.10)	(0.14)
Dep. Variable Mean	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51
Year/Segment FEs		Yes	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes	Yes	Yes
Drop Independents				Yes		
Drop 2008					Yes	
Instrument			Yes	Yes	Yes	Yes
Use Employment						Yes
Hausman Test			0.00	0.13	0.00	0.67
Adj. R-squared (1st Stage)			0.81	0.76	0.80	0.55
Adj. R-squared	0.09	0.74	0.74	0.73	0.75	0.74
Num. Observations	2063	2063	2063	1792	1549	2063

Alternative weighted regression results for several alternative versions of the regression specified in equation 2 for hotels, using the number of hotels at the metro area-segment-year level as weights. The estimated coefficient of demand volatility is reported for all specifications in the first row, with the standard errors clustered at the metro area level reported in the second row within parentheses. Additional statistics for each specification are given including the mean of the dependent variable over the estimation sample, p-value of the Hausman endogeneity test (if applicable), the adjusted R^2-statistic of the first stage regression (if applicable), the adjusted R^2-statistic, and the number of observations. Specification (a) reports the coefficient, absent any fixed effects or metro area-year controls. Specification (b) adds a set of controls at the metro area-year level including: logarithm of the average salary in the leisure and hospitality sector, logarithm of the U.S. Department of Housing and Urban Development's fair market rent for a three-bedroom, logarithm of the average price of electricity for commercial customers, logarithm of personal income per capita, logarithm of personal income, logarithm of employment in the leisure and hospitality sector, the unemployment rate, the logarithm of the share of total non-farm employment in the leisure and hospitality sector, logarithm of employees in leisure and hospitality sector per square mile, five-year log change in personal income per capita, five-year log change in personal income, and five-year log change in employment in the leisure and hospitality as well as year and segment fixed effects. In specifications (c)-(f), an instrument is used for demand volatility (see section II.D). Specification (d) reports the coefficient when one drops the segment-year observations that involve independently affiliated hotels. Specification (e) reports the coefficient when one drops the segment-year observations that were in 2008. Specification (f) reports the coefficient when one uses the annual coefficient of variation in employment in leisure and hospitality at the metro area-year level as the instrument for demand volatility.

Table 3: List of STR Metro Markets Included in the Hotel Sample

Albany/Schenectady, NY	Macon/Warner Robbins, GA
Albuquerque, NM	Madison, WI
Allentown/Reading, PA	Maui Island, HI
Anaheim/Santa Ana, CA	McAllen/Brownsville, TX
Atlanta, GA	Melbourne/Titusville, FL
Augusta, GA-SC	Memphis, TN-AR-MS
Austin, TX	Miami/Hialeah, FL
Baltimore, MD	Milwaukee, WI
Bergen/Passaic, NJ	Minneapolis/St Paul, MN-WI
Birmingham, AL	Mobile, AL
Boston, MA	Myrtle Beach, SC
Buffalo, NY	Nashville, TN
Charleston, SC	New Orleans, LA
Charlotte, NC-SC	New York, NY
Chattanooga, TN-GA	Newark, NJ
Chicago, IL	Norfolk/Virginia Beach, VA
Cincinnati, OH-KY-IN	Oahu Island, HI
Cleveland, OH	Oakland, CA
Colorado Springs, CO	Oklahoma City, OK
Columbia, SC	Omaha, NE
Columbus, OH	Orlando, FL
Dallas, TX	Philadelphia, PA-NJ
Dayton/Springfield, OH	Phoenix, AZ
Daytona Beach, FL	Pittsburgh, PA
Denver, CO	Portland, OR
Des Moines, IA	Raleigh/Durham/Chapel Hill, NC
Detroit, MI	Richmond/Petersburg, VA
Fort Lauderdale, FL	Riverside/San Bernardino, CA
Fort Myers, FL	Rochester, NY
Fort Worth/Arlington, TX	Sacramento, CA
Grand Rapids, MI	Salt Lake City/Ogden, UT
Greensboro/Winston Salem, NC	San Antonio, TX
Greenville/Spartanburg, SC	San Diego, CA
Harrisburg, PA	San Francisco/San Mateo, CA
Hartford, CT	San Jose/Santa Cruz, CA
Houston, TX	Sarasota/Bradenton, FL
Indianapolis, IN	Savannah, GA
Jackson, MS	Scranton/Wilkes-Barre, PA
Jacksonville, FL	Seattle, WA
Kansas City, MO-KS	St Louis, MO-IL
Knoxville, TN	Syracuse, NY
Las Vegas, NV	Tampa/St Petersburg, FL
Lexington, KY	Tucson, AZ
Little Rock, AR	Tulsa, OK
Los Angeles/Long Beach, CA	Washington, DC-MD-VA
Louisville, KY-IN	West Palm Beach/Boca Raton, FL

Table 4: List of STR Metro Markets and Census MSA or Metro Division Equivalent

STR Market	MSA or Metro Division Equivalent
Birmingham, AL	Birmingham-Hoover
Mobile, AL	Mobile
Phoenix, AZ	Phoenix-Mesa-Scottsdale
Tucson, AZ	Tucson
Little Rock, AR	Little Rock-North Little Rock
Anaheim/Santa Ana, CA	Santa Ana-Anaheim-Irvine CA Metro Division
Los Angeles/Long Beach, CA	Los Angeles-Long Beach-Glendale Metro Division
Oakland, CA	Oakland-Fremont-Hayward Metro Division
Riverside/San Bernardino, CA	Riverside-San Bernardino-Ontario PMSA
Sacramento, CA	Sacramento-Arden-Arcade-Roseville
San Diego, CA	San Diego-Carlsbad-San Marcos
San Francisco/San Mateo, CA	San Francisco-San Mateo-Redwood City Metro Division
San Jose/Santa Cruz, CA	San Jose-Sunnyvale-Santa Clara + Santa Cruz-Watsonville
Denver, CO	Denver-Aurora
Colorado Springs, CO	Colorado Springs
Hartford, CT	Hartford-West Hartford-East Hartford
Washington, DC-MD-VA	Washington, DC PMSA
Fort Lauderdale, FL	Fort Lauderdale-Pampano Beach-Deerfield Beach Metro Division
Jacksonville, FL	Jacksonville
Miami/Hialeah, FL	Miami-Miami Beach-Kendall Metro Division
Orlando, FL	Orlando
Tampa/St Petersburg, FL	Tampa - St. Petersburg - Clearwater
West Palm Beach/Boca Raton, FL	West Palm Beach - Boca Raton - Boynton Metro Division
Fort Myers, FL	Cape Coral - Fort Myers
Daytona Beach, FL	Deltona - Daytona Beach - Ormond Beach
Melbourne/Titusville, FL	Palm Bay - Melbourne -Titusville
Sarasota/Bradenton, FL	North Port - Bradenton - Sarasota
Atlanta, GA	Atlanta - Sandy Springs - Marietta
Macon/Warner Robins, GA	Macon + Warner Robins
Augusta, GA-SC	Augusta - Richmond
Savannah, GA	Savannah
Oahu Island, HI	Honolulu
Maui Island, HI	Kahului-Wailuku-Lahaina
Chicago, IL	Chicago - Naperville - Joliet Metro Division
Indianapolis, IN	Indianapolis
Des Moines, IA	Des Moines
Louisville, KY-IN	Louisville
Lexington, KY	Lexington-Fayette
New Orleans, LA	New Orleans - Metairie - Kenner
Baltimore, MD	Baltimore - Towson
Boston, MA	Boston - Cambridge - Quincy Metro Division
Detroit, MI	Detroit - Livonia - Dearborn Metro Division
Grand Rapids, MI	Grand Rapids - Wyoming
Minneapolis/St Paul, MN-WI	Minneapolis - St Paul - Bloomington
Jackson, MS	Jackson
Kansas City, MO-KS	Kansas City MO-KS

Table 5: List of STR Metro Markets and Census MSA or Metro Division Equivalent (Continued)

STR Market	MSA or Metro Division Equivalent
St Louis, MO-IL	St Louis
Omaha, NE	Omaha - Council Bluffs
Las Vegas, NV	Las Vegas - Paradise
Bergen/Passaic, NJ	Bergen - Hudson - Passaic
Newark, NJ	Newark - Union Metro Division
Albuquerque, NM	Albuquerque
New York, NY	NY - Wayne - White Plains Metro Division
Syracuse, NY	Syracuse
Albany/Schenectady, NY	Albany - Schenectady - Troy
Buffalo, NY	Buffalo - Niagara Falls
Rochester, NY	Rochester
Charlotte, NC-SC	Charlotte - Gastonia - Rock Hill
Greensboro/Winston Salem, NC	Greensboro - High Point + Winston-Salem
Raleigh/Durham/Chapel Hill, NC	Raleigh-Cary + Durham
Cincinnati, OH-KY-IN	Cincinnati - Middletown
Cleveland, OH	Cleveland - Elyria - Mentor
Columbus, OH	Columbus
Dayton/Springfield, OH	Dayton + Springfield
Oklahoma City, OK	Oklahoma City
Tulsa, OK	Tulsa
Portland, OR	Portland - Vancouver - Beaverton
Philadelphia, PA-NJ	Philadelphia Metro Div
Pittsburgh, PA	Pittsburgh
Scranton/Wilkes-Barre, PA	Scranton - Wilkes - Barre - Hazleton
Harrisburg, PA	Harrisburg - Carlisle
Allentown/Reading, PA	Allentown - Bethlehem - Easton + Reading
Greenville/Spartanburg, SC	Greenville + Spartanburg
Columbia, SC	Columbia
Charleston, SC	Charleston - North Charleston
Myrtle Beach, SC	Myrtle Beach - Conway - North Myrtle Beach
Knoxville, TN	Knoxville
Memphis, TN-AR-MS	Memphis
Nashville, TN	Nashville - Davidson - Murfreesboro
Chattanooga, TN-GA	Chattanooga
Austin, TX	Austin - Round Rock
Dallas, TX	Dallas - Plano - Irving Metro Division
Fort Worth/Arlington, TX	Fort Worth - Arlington Metro Division
Houston, TX	Houston - Sugar Land - Baytown
San Antonio, TX	San Antonio
McAllen/Brownsville, TX	McAllen - Edinburg - Pharr + Brownsville - Harlingen - San Benito
Salt Lake City/Ogden, UT	Salt Lake City + Ogden - Clearfield
Norfolk/Virginia Beach, VA	Virginia Beach - Norfolk - Newport News
Richmond/Petersburg, VA	Richmond
Seattle, WA	Seattle - Tacoma - Bellevue
Milwaukee, WI	Milwaukee - Waukesha - W Allis
Madison, WI	Madison

Table 6: List of Airports Included in the Airline Sample

	American Airlines/Delta/United/US Air	**Southwest**
Birmingham, AL	Shuttlesworth International	x
Phoenix, AZ	Sky Harbor International	x
Tucson, AZ	Tucson International	x
Little Rock, AR	Bill and Hillary Clinton	x
Anaheim/Santa Ana, CA	John Wayne Airport	x
Los Angeles/Long Beach, CA	Los Angeles International	x
Oakland, CA	Metropolitan Oakland International	x
Sacramento, CA	Sacramento International	x
San Diego, CA	San Diego International	x
San Francisco/San Mateo, CA	San Francisco International	x
San Jose/Santa Cruz, CA	Norman Y. Mineta International	x
Denver, CO	Denver International	x
Colorado Springs, CO	City of Colorado Springs Municipal	x
Hartford, CT	Bradley International	x
Washington, DC-MD-VA	Ronald Reagan Washington	x
Fort Lauderdale, FL	Ft. Lauderdale-Hollywood	x
Jacksonville, FL	Jacksonville International	x
Miami/Hialeah, FL	Miami International	x
Orlando, FL	Orlando International	x
Tampa/St Petersburg, FL	Tampa International	x
West Palm Beach/Boca Raton, FL	Palm Beach International	x
Fort Myers, FL	Southwest Florida International	x
Atlanta, GA	Hartsfield-Jackson International	x
Oahu Island, HI	Honolulu International	x
Chicago, IL	O'hare International	Midway
Indianapolis, IN	Indianapolis International	x
Louisville, KY-IN	Louisville International-Standiford Field	x
New Orleans, LA	Louis Armstrong	x
Baltimore, MD	Baltimore/Washington International	x
Boston, MA	Logan International	x

Table 7: List of Airports Included in the Airline Sample (Continued)

	American Airlines/Delta/United/US Air	**Southwest**
Detroit, MI	Detroit Metro Wayne County	x
Minneapolis/St Paul, MN-WI	Minneapolis International	x
Kansas City, MO-KS	Kansas City International	x
St Louis, MO-IL	Lambert-St. Louis International	x
Omaha, NE	Eppley Airfield	x
Las Vegas, NV	McCarran International	x
Newark, NJ	Newark Liberty International	x
Albuquerque, NM	Albuquerque International Sunport	x
New York, NY	John F. Kennedy International	x
Albany/Schenectady, NY	Albany International	x
Buffalo, NY	Buffalo Niagara International	x
Charlotte, NC-SC	Charlotte Douglas International	x
Raleigh/Durham/Chapel Hill, NC	Raleigh-Durham International	x
Cincinnati, OH-KY-IN	Cincinnati/Northern Kentucky International	x
Cleveland, OH	Cleveland-Hopkins International	x
Columbus, OH	Port Columbus International	x
Dayton/Springfield, OH	James M. Cox/Dayton International	x
Oklahoma City, OK	Will Rogers World	x
Tulsa, OK	Tulsa International	x
Portland, OR	Portland International	x
Philadelphia, PA-NJ	Philadelphia International	x
Pittsburgh, PA	Pittsburgh International	x
Memphis, TN-AR-MS	Memphis International	x
Nashville, TN	Nashville International	x
Austin, TX	Bergstrom International	x
Dallas, TX	Dallas/Fort Worth International	Love Field
Houston, TX	George Bush Intercontinental	Hobby
San Antonio, TX	San Antonio International	x
Salt Lake City/Ogden, UT	Salt Lake City International	x
Norfolk/Virginia Beach, VA	Norfolk International	x
Richmond/Petersburg, VA	Richmond International	x
Seattle, WA	Seattle/Tacoma International	x

Table 8: Summary of Sources for Data Included in the Hotel and Airline Analysis

Variable	**Units**	**Application**	**Geographic Identifier**	**Source**
Leisure/Hospitality Employment	# of Employees	Hotel	MSA/Division	Bureau of Labor Statistics
Non-farm Employment	# of Employees	Airline/Hotel	MSA/Division	Bureau of Labor Statistics
Unemployment Rate	% Rate	Airline/Hotel	MSA/Division	Bureau of Labor Statistics
Personal Income	$ Dollars	Airline/Hotel	MSA/Division	Bureau of Economic Analysis
Personal Income/Capita	$ Dollars/capita	Airline/Hotel	MSA/Division	Bureau of Economic Analysis
Fair Market Rent (3-Bedroom)	$ Dollars	Airline/Hotel	County	Housing & Urban Development
Commerical Electricity Price	Cents/Kilowatt hour	Airline/Hotel	State	Energy Information Administration
Leisure & Hospitality Sector Salary	$/year	Hotel	MSA/County	Bureau of Labor Statistics
Passenger Facility Charge	% Rate	Airline	Airport	Bureau of Transportation Statistics
Population	# of Residents	Airline/Hotel	MSA/Division/County	Census
Land Area	Square Mile	Hotel	MSA/Division/County	State-Metropolitan Area Data Book, County-City Data Book

Table 9: Summary of Data Included in the Hotel Regressions

	Mean	Std	Min	Max
log Avg. Annual Salary in Leisure & Hospitality ($1000)	9.79	0.23	9.31	10.44
log Fair Market 3-br Rent ($/sqft)	6.97	0.27	6.13	7.77
log Avg. Commercial Electricity Price (cent/kwh)	2.27	0.27	1.81	3.39
log Personal Income per capita (thous. $/capita)	10.59	0.17	9.85	11.18
log Personal Income (thous. $)	17.83	0.86	15.44	20.41
log Employment in Leisure & Hospitality (thous.)	4.18	0.77	2.74	6.03
Unemployment Rate (%)	5.84	2.26	2.41	16.13
log Share of Employment in Leisure & Hospitality (%)	-2.29	0.26	-2.74	-1.14
log Employment in Leisure & Hospitality/per Square Mile (number/sq mile)	3.09	0.85	1.39	5.55
Five-year log diff Personal Income per capita (thous. $/capita)	0.19	0.06	0.04	0.46
Five-year log diff Personal Income (thous. $)	0.25	0.07	0.00	0.50
Five-year log diff Leisure & Hospitality Emp. (thous.)	0.09	0.07	-0.35	0.29
Alternative Demand Volatility ($\eta = 1.85$)	0.30	0.16	0.06	1.30
Alternative Demand Volatility ($\eta = 4$)	0.52	0.44	0.09	4.12

Source: QCEW for the average wage in the leisure and hospitality sector, HUD for the fair market 3-bedroom rent, BEA for the personal income and personal income per capita as well as the five year growth rates in each variable, BLS for the unemployment rate and employment in the leisure and hospitality sector, as well as the share of total non-farm employment in the leisure of hospitality sector and the five-year growth rate, and EIA for the average commercial price of electricity.

Table 10: Summary of Data Included in the Airline Regressions

	Mean	Std	Min	Max
log Avg. Commercial Electricity Price (cent/kwh)	2.23	0.27	1.68	3.55
log Fair Market 3-br Rent ($/sqft)	7.09	0.27	6.58	7.90
Passenger Facility Charge (%)	4.10	0.94	0.00	4.50
Unemployment Rate (%)	6.53	2.34	2.41	16.13
log Employment in Non-farm (thous.)	6.91	0.63	5.24	8.60
log Personal Income (thous. $)	18.29	0.68	16.62	20.23
log Personal Income per capita ($/capita)	10.63	0.19	10.23	11.38
Five-year log diff Non-farm Emp. (thous.)	0.07	0.07	-0.35	0.31
Five-year log diff Personal Income (thous. $)	0.21	0.09	-0.04	0.57
Five-year log diff Personal Income per capita (thous. $/capita)	0.15	0.08	-0.12	0.50

Source: BTS and author's calculations for the load factor and coefficient of variation of demand, HUD for the fair market 3-bedroom rent, BEA for the personal income and personal income per capita as well as the five year growth rates in each variable, BLS for the unemployment rate and the five-year growth rate in non-farm employment, and the BTS for the passenger facility charge.

Table 11: Regression Results Allowing for Increasing Returns to Scale

	(a)	(b)	(c)	(d)	(e)	(f)
Demand Volatility	-0.82	-0.38	-0.29	-0.32	-0.26	-0.39
	(0.12)	(0.08)	(0.10)	(0.11)	(0.10)	(0.15)
Dep. Variable Mean	-1.07	-1.07	-1.07	-1.06	-1.07	-1.07
Year/Segment FEs		Yes	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes	Yes	Yes
Drop Independents				Yes		
Drop 2008					Yes	
Instrument			Yes	Yes	Yes	Yes
Use Employment						Yes
Hausman Test			0.04	0.19	0.03	0.97
Adj. R-squared (1st Stage)			0.70	0.69	0.69	0.49
Adj. R-squared	0.10	0.68	0.68	0.67	0.69	0.68
Num. Observations	2063	2063	2063	1792	1549	2063

Regression results for several alternative versions of the regression specified in equation 2 with alternative capacity utilization measure assuming increasing returns to scale of 1.04. The estimated coefficient of demand volatility is reported for all specifications in the first row, with the standard errors clustered at the metro area level reported in the second row within parentheses. Additional statistics for each specification are given including the mean of the dependent variable over the estimation sample, p-value of the Hausman endogeneity test (if applicable), the adjusted R^2-statistic of the first stage regression (if applicable), the adjusted R^2-statistic, and the number of observations. Specification (a) reports the coefficient, absent any fixed effects or metro area-year controls. Specification (b) adds a set of controls at the metro area-year level including: logarithm of the average salary in the leisure and hospitality sector, logarithm of the U.S. Department of Housing and Urban Development's fair market rent for a three- bedroom, logarithm of the average price of electricity for commercial customers, logarithm of personal income per capita, logarithm of personal income, logarithm of employment in the leisure and hospitality sector, the unemployment rate, the logarithm of the share of total non-farm employment in the leisure and hospitality sector, logarithm of employees in leisure and hospitality sector per square mile, five-year log change in personal income per capita, five-year log change in personal income, and five-year log change in employment in the leisure and hospitality as well as year and segment fixed effects. In specifications (c)-(f), an instrument is used for demand volatility (see section II.D). Specification (d) reports the coefficient when one drops the segment-year observations that involve independently affiliated hotels. Specification (e) reports the coefficient when one drops the segment-year observations that were in 2008. Specification (f) reports the coefficient when one uses the annual coefficient of variation in employment in leisure and hospitality at the metro area-year level as the instrument for demand volatility.

Table 12: Regression Results for Alternative Measure of Demand Volatility

	(a)	(b)	(c)	(d)	(e)	(f)
Demand Volatility	-0.04	-0.03	-0.03	-0.04	-0.03	-0.05
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Dep. Variable Mean	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
Year/Segment FEs		Yes	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes	Yes	Yes
Drop Independents				Yes		
Drop 2008					Yes	
Instrument			Yes	Yes	Yes	Yes
Use Employment						Yes
Hausman Test			0.66	0.60	0.65	0.18
Adj. R-squared (1st Stage)			0.80	0.78	0.80	0.55
Adj. R-squared	0.01	0.71	0.71	0.71	0.72	0.70
Num. Observations	2063	2063	2063	1792	1549	2063

Regression results for several alternative versions of the regression specified in equation 2 with alternative demand volatility measure and price elasticity of demand of 4. The estimated coefficient of demand volatility is reported for all specifications in the first row, with the standard errors clustered at the metro area level reported in the second row within parentheses. Additional statistics for each specification are given including the mean of the dependent variable over the estimation sample, p-value of the Hausman endogeneity test (if applicable), the adjusted R^2-statistic of the first stage regression (if applicable), the adjusted R^2-statistic, and the number of observations. Specification (a) reports the coefficient, absent any fixed effects or metro area-year controls. Specification (b) adds a set of controls at the metro area-year level including: logarithm of the average salary in the leisure and hospitality sector, logarithm of the U.S. Department of Housing and Urban Development's fair market rent for a three-bedroom, logarithm of the average price of electricity for commercial customers, logarithm of personal income per capita, logarithm of personal income, logarithm of employment in the leisure and hospitality sector, the unemployment rate, the logarithm of the share of total non-farm employment in the leisure and hospitality sector, logarithm of employees in leisure and hospitality sector per square mile, five-year log change in personal income per capita, five-year log change in personal income, and five-year log change in employment in the leisure and hospitality as well as year and segment fixed effects. In specifications (c)-(f), an instrument is used for demand volatility (see section II.D). Specification (d) reports the coefficient when one drops the segment-year observations that involve independently affiliated hotels. Specification (e) reports the coefficient when one drops the segment-year observations that were in 2008. Specification (f) reports the coefficient when one uses the annual coefficient of variation in employment in leisure and hospitality at the metro area-year level as the instrument for demand volatility.

Table 13: Regression Results for Revenue Per Available Room

	(a)	(b)	(c)	(d)	(e)	(f)
Demand Volatility	-1.69	0.17	0.42	0.27	0.44	0.52
	(0.35)	(0.12)	(0.17)	(0.15)	(0.17)	(0.19)
Dep. Variable Mean	4.01	4.01	4.01	4.01	4.00	4.01
Year/Segment FEs		Yes	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes	Yes	Yes
Drop Independents				Yes		
Drop 2008					Yes	
Instrument			Yes	Yes	Yes	Yes
Use Employment						Yes
Hausman Test			0.01	0.02	0.02	0.03
Adj. R-squared (1st Stage)			0.70	0.69	0.69	0.49
Adj. R-squared	0.03	0.90	0.90	0.92	0.90	0.90
Num. Observations	2063	2063	2063	1792	1549	2063

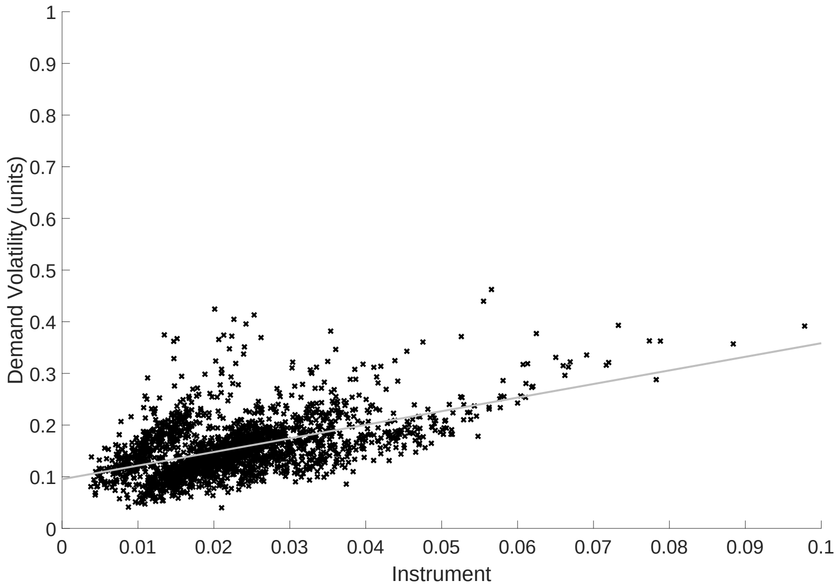
Regression results for several alternative versions of the regression specified in equation 2 but with the logarithm of revenue per available room night as the dependent variable. The estimated coefficient of demand volatility is reported for all specifications in the first row, with the standard errors clustered at the metro area level reported in the second row within parentheses. Additional statistics for each specification are given including the mean of the dependent variable over the estimation sample, p-value of the Hausman endogeneity test (if applicable), the adjusted R^2-statistic of the first stage regression (if applicable), the adjusted R^2-statistic, and the number of observations. Specification (a) reports the coefficient, absent any fixed effects or metro area-year controls. Specification (b) adds a set of controls at the metro area-year level including: logarithm of the average salary in the leisure and hospitality sector, logarithm of the U.S. Department of Housing and Urban Development's fair market rent for a three-bedroom, logarithm of the average price of electricity for commercial customers, logarithm of personal income per capita, logarithm of personal income, logarithm of employment in the leisure and hospitality sector, the unemployment rate, the logarithm of the share of total non-farm employment in the leisure and hospitality sector, logarithm of employees in leisure and hospitality sector per square mile, five-year log change in personal income per capita, five-year log change in personal income, and five-year log change in employment in the leisure and hospitality as well as year and segment fixed effects. In specifications (c)-(f), an instrument is used for demand volatility (see section II.D). Specification (d) reports the coefficient when one drops the segment-year observations that involve independently affiliated hotels. Specification (e) reports the coefficient when one drops the segment-year observations that were in 2008. Specification (f) reports the coefficient when one uses the annual coefficient of variation in employment in leisure and hospitality at the metro area-year level as the instrument for demand volatility.

Table 14: Summary of Expected Signs and Estimated Coefficient for a Selection of Controls

Observable for Hotels	Expected Sign	Coefficient	Significant for (b)-(f)
Avg. Hotel Salary	(+)	(+)	✓
Fair Market Rent	(+)	(+)	✓
Avg. Electricity Price	(+)	(+)	
Personal Income per capita	(−)	(−)	
Emp in Leisure & Hospitality	(+)	(+)	
Unemployment Rate	(−)	(−)	✓

This table summarizes the coefficient estimates of some of the variables included in the regressions as controls in the hotel application. For each variable used, the expected sign of the estimated coefficient, the sign of the estimated coefficient in all specifications, and if that coefficient was statistically significant from zero (at a 5 percent level) for all of the regressions specifications (b)-(f) in table 2, are reported across the columns.

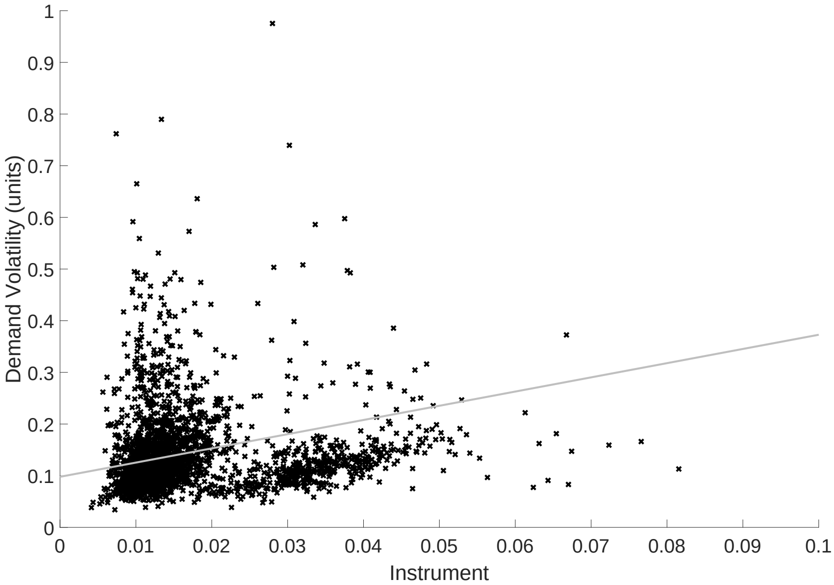
Figure 4: Demand Volatility and Instrument for all Metro area-Segment-Years



Source: Smith Travel Research and author's calculations

Scatter plot of the 2,063 metro area-segment-years. On the vertical axis is the measure of demand volatility given by equation 1, while on the horizontal axis is the measure of the instrument given by equations 3-4. For an explicit summary of the data see section III.

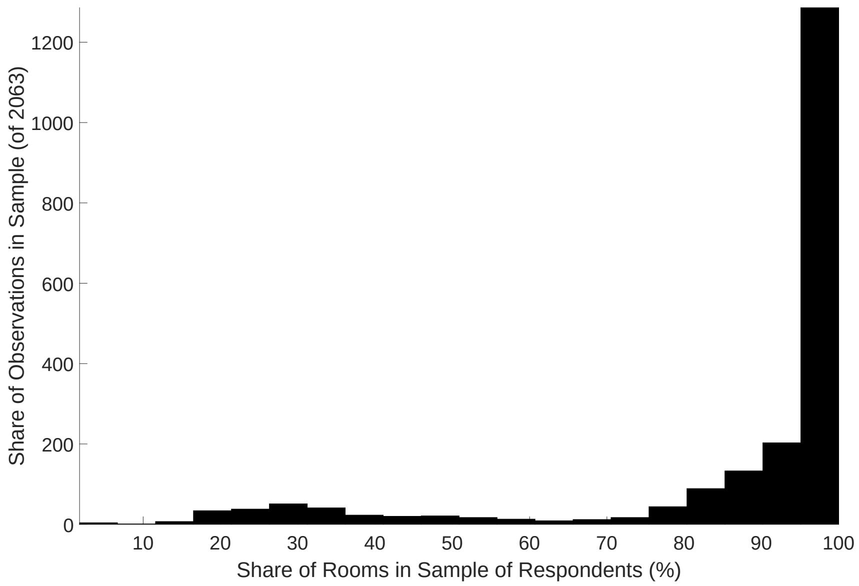
Figure 5: Demand Volatility and Instrument for all Airline-Destination-Years



Source: Bureau of Transportation Statistics and author's calculations

Scatter plot of the 2,414 destination-airline-years. On the vertical axis is the measure of demand volatility given by equation 1, while on the horizontal axis is the measure of the instrument given by equations 3-4. For an explicit summary of the data see section III.

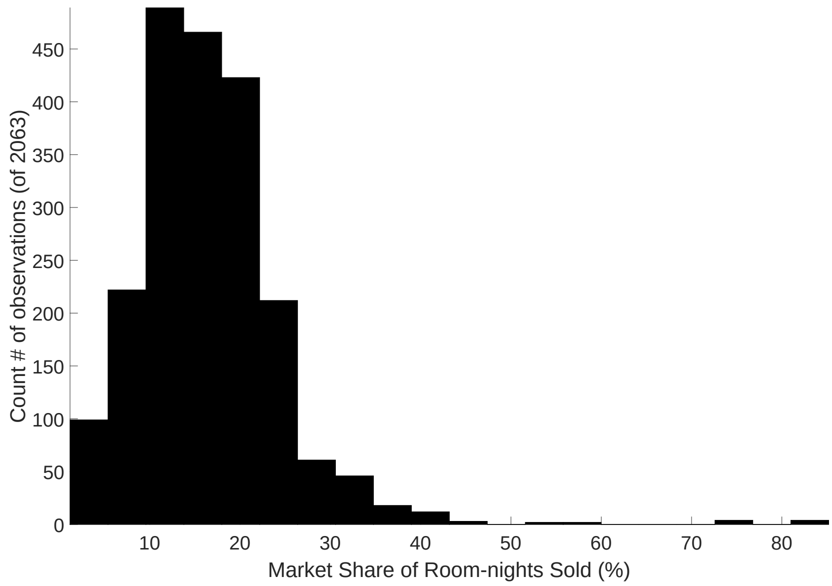
Figure 6: Histogram of Share of Rooms Covered by STR Respondents for all Metro area-Segment-Years



Source: Smith Travel Research and author's calculations

This figure displays the histogram for the 2,063 metro area-segment-year observations of the respondent share as measured by number of rooms in the STR sample. For an explicit summary of the data see section III.

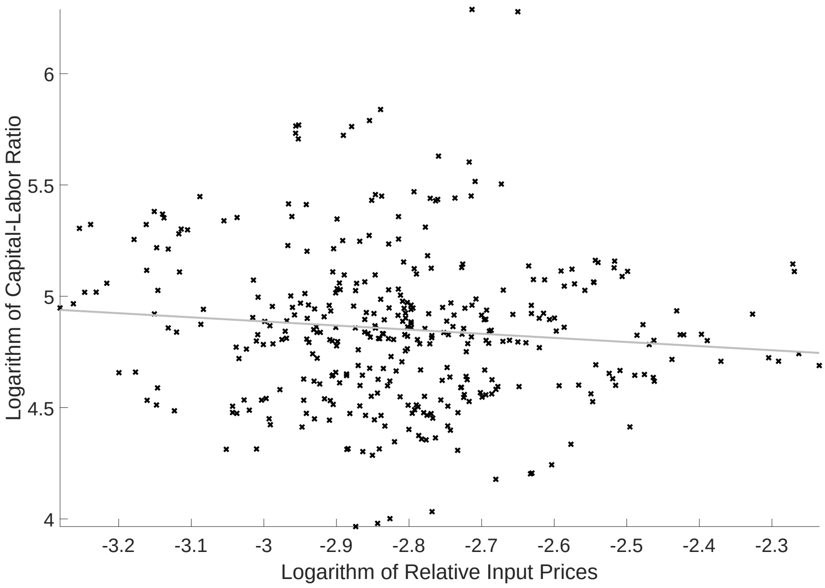
Figure 7: Histogram of Market Shares (Room-nights Sold) for all Metro area-Segment-Years



Source: Smith Travel Research and author's calculations

This figure displays the histogram of the market shares as measured by the share of room-nights sold a segment sells of the total for the metro area in a year. For an explicit summary of the data see section III.

Figure 8: Capital-Labor Ratios and Relative Input Prices for All Metro Area-Years in Hotel Sample



Source: Smith Travel Research, County Business Patterns, and author's calculations

This figure displays the capital-labor ratio and the relative input prices for all the metro area-year observations in the hotel sample. Along the vertical axis is the measure of the capital-labor ratio, while along the horizontal axis is the measure of relative input prices (logarithm of fair market rent for a three-bedroom over average employee salary in the leisure and hospitality sector). For an explicit summary of the data see section III.

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