The Volatility of Real Estate Markets: *A Decomposition*

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This research examines the volatility of real estate markets across U.S. metro areas. The analysis is illustrated for four property types—full service hotels, office buildings, apartments, and industrial structures—but it is applicable to any type of real estate with accurate data. The article's innovation is to use the volatility in vacancy rates (actually the volatility in vacancy rate changes) rather than volatility in rents, prices, or investment "return." There is a long literature linking rental movements to those in vacancy (Rosen and Smith [1983]), but by focusing directly on vacancy as our metric, market volatility can be explicitly apportioned into supply-side and demand-side shares. This decomposition can be done exactly—without any econometric application. This decomposition varies across markets and is systematically different for each property type. For investment analysis, this provides an incredibly simple metric of "market risk" and where it comes from.

With this analysis, the article makes an initial attempt to examine the correlates of both the overall variance of vacancy as well as the partition of this variance into demand/supply "shares." Often these associations are complex. For example, faster growth in a market's underlying economy, as well as higher volatility around that growth, both generate greater demand-side volatility. At the same time, often such markets have supply that is better "coordinated"—leading to little impact or lower levels of overall volatility. Similarly, a widely used measure of regulatory delay is associated with a larger volatility contribution from the supply side, but areas with such regulations also happen to have lower demand volatility—which on net just offsets the impact from the supply side. The analysis thus suggests that regulatory controls may be endogenous and at least partly determined by the behavior of an area's economy and its real estate market. The results also reveal that the correlates of commercial property decompositions are different than those for apartments.

LITERATURE REVIEW

Real estate volatility is most often discussed in the context of "cycles." The brief summary here will do only partial justice to the lengthy literature. The literature begins with articles on the U.S. construction cycle, in particular for the housing industry that emerged during the post-World War II economic boom.[1] Much of this discussion focuses on the supply of credit to the building industry as the U.S. Federal Reserve Bank fought bouts of economic inflation.

The discussion then shifts to the demand side of the market. Poterba [1982] argued that some cyclic movement in real estate prices is inevitable—due to building lags—as markets react to demand shocks with forward expectations. Mankiw and Weil [1989] provided a counterargument that expectations are highly imperfect because the impact to the housing market of the "baby boom" shock occurs when such children enter the housing market—not when they were born (and information is first revealed). Case and Shiller [1989] provided several additional arguments supporting the view that irrational buyer expectations contribute to market fluctuations. Stein [1995] suggested that institutional credit constraints inhibit and encourage buyers—rather than "irrational" expectations.

In discussing commercial real estate, a number of authors note the presence of longer-term building cycles that seem to be unrelated to the broader economic or credit cycle.[2] In a series of papers, Grenadier [1995, 1996] showed that the exercise of development options could result in building "cascades"—shifting the blame for real estate oscillations back again to the supply side. Macro and financial economists joined the debate demonstrating that with collateral constraints, development credit can in fact exhibit "herd behavior."[3] The emphasis on supply as a source of market rigidities and oscillations continues with recent empirical work to identify housing supply elasticities and link them to natural or institutional constraints.[4] Recently, a series of empirical papers examined the long-term volatility of housing prices in relation to price growth (return) as well as to rent fundamentals.[5]

Two observations seem in order in reviewing this literature. First, the focus has mostly been on the volatility of asset prices, rents, and construction. Few, if any, papers have even mentioned the role of vacancy and its cyclic movements. Second, most work tends to focus exclusively on one side of the market or the other. There really has been no empirical attempt to partition or assign responsibility for volatility to both sides of the market. This article will begin to fill this gap.

DECOMPOSING THE VOLATILITY IN VACANCY

The analysis begins with a set of definitions of market variables in Equation (1). Using these definitions, the last identity (1) is well known.

$$\begin{aligned} &V_t\text{: vacancy rate}\\ &S_t\text{: stock of space}\\ &OS_t\text{: occupied space (demand ex post)}\\ &(1-V_t) = OS_t/S_t \end{aligned} \tag{1}$$

It is possible to linearly decompose the occupancy rate (1 minus the vacancy rate) into demand and supply components, but this requires taking the log of the ratio of space occupied to that of total space supplied.[6] The variance of a log variable can be quite sensitive to the measurement scale of the variable, and this would influence any variance decomposition. Instead, it was decided to work with the first differences of the variables in (1) and as such to examine the *flows* of supply and demand and their respective impacts on the *changes* in vacancy. This is done in Equation (2) by identifying the change in the stock of space and the change in space consumption (ex post demand growth)—measured as rates (fractions of the stock). These can then be linked linearly to the change in the vacancy rate.

$$\begin{aligned} &C_t\text{ : space completions}\\ &\mathrm{A_t}\text{ : net space absorption }(OS_t - OS_{t-1})\\ &S_t - S_{t-1} = C_t\\ &A_t = C_t - (V_t - V_{t-1})S_t\\ &V_t - V_{t-1} = C_t/S_t - A_t/S_t \end{aligned} \tag{2}$$

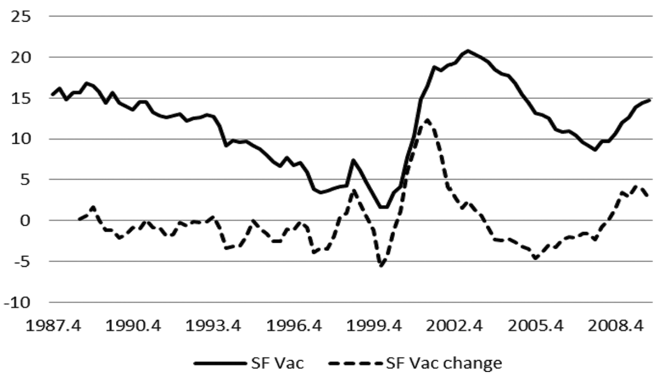
In Equation (2), net absorption (the growth in ex post demand or occupied space) is defined as completions minus the change in vacancy in the full stock (including the new completions). This definition is slightly different from one often used in the profession—the change in total occupied space.[7] With this definition, the bottom identity in (2) holds exactly. Hence, there is a simple linear relationship between the change in the vacancy rate and the new supply rate minus the demand growth rate. Exhibit 1 illustrates the movement in vacancy changes as opposed to vacancy levels for the San Francisco office market. It is the former that will be decomposed rather than the latter.

With the last identity in (2), Equation (3) exactly breaks apart the volatility in vacancy (or rather vacancy changes) into three components: 1) that due to demand growth (net absorption), 2) that due to supply growth (completions), and 3), equally important, the correlation or covariance between completions and absorption.

$$\begin{aligned} \sigma^2(V_t - V_{t-1}) &= \sigma^2(A_t/S_t) + \sigma^2(C_t/S_t)\\ &\quad - 2\,\mathrm{cov}(A_t/S_t, C_t/S_t)\\ &= \sigma^2(A_t/S_t) + \sigma^2(C_t/S_t)\\ &\quad - 2\sigma(A_t/S_t)\sigma(C_t/S_t)\mathrm{corr}(A_t/S_t, C_t/S_t) \end{aligned} \tag{3}$$

EXHIBIT 1

San Francisco Office Vacancy Levels/Changes



The third component—the covariance between the two sides of the market place—plays a pivotal role. If supply and demand are highly correlated contemporaneously, then there will be little movement in a market's vacancy rate. A change in vacancy results when the two sides of the market *move different amounts in the same period and/or move at different periods.* Hence, differences with demand in the magnitude or timing of supply will tend to generate a larger positive third term. To better see this, the second expression in (3) is examined in more detail and then rearranged into Equation (4). Here the variance in vacancy can be divided up into just two terms: one for demand (absorption) and the other for supply (completions adjusted for timing). These two terms can be thought of as the contributory share (to vacancy variance) from each side of the market.

$$\begin{aligned}&\sigma^2(V_t - V_{t-1})\\ &\quad = \sigma^2(A_t/S_t) + \sigma^2(C_t/S_t)\left[1 - 2\mathrm{corr}(A_t/S_t, C_t/S_t)\frac{\sigma(A_t/S_t)}{\sigma(C_t/S_t)}\right]\\ &\quad = \text{Demand} \; + \qquad\qquad \ldots \text{Supply} \ldots\end{aligned} \tag{4}$$

Taking the derivative of the variance in vacancy movements with respect to the variance in supply, we get expression (5). This is the contribution of a unit increase in supply variance to the overall variance in vacancy changes or market volatility.

$$\frac{\partial\sigma^2(V_t - V_{t-1})}{\partial\sigma^2(C_t/S_t)} = 1 - \mathrm{corr}(A_t/S_t, C_t/S_t)\frac{\sigma(A_t/S_t)}{\sigma(C_t/S_t)} \tag{5}$$

In expression (5), it's clear that a higher variance of supply *increases* overall market variance (a positive derivative here) in two situations. First, when there is *any* negative correlation between the two. Second, when there is the combination of a positive correlation, together with a supply variance that is sufficiently large relative to the variance in demand. The first of these is an error in timing, the second is an error in magnitude. On the other hand, greater supply-side variance can actually *reduce* overall market vacancy when 1) the correlation between sides of the market is positive and 2) the variance in completions is sufficiently small relative to that in demand. This latter case is particularly insightful, for it reveals that supply actually can be a "friend" of investors in certain situations—by dampening market volatility. Creating new development that is not overly large (or overly small) and creating it when it is needed (as opposed to not needed) is the key to keeping vacancy smooth and even. With smooth vacancy, rents, income, and investment return should all be smoother as well.

To further illustrate the role of supply, one might assume that the variance in absorption comes from true demand-side random "shocks," while the variance in supply depends on the endogenous pattern of market response. This perception of how market volatility arises is certainly quite common in the literature (Wheaton [1999]). In this case, long-run absorption and completion rates must be approximately equal because vacancy rates in general are stationary and without a long-run trend. Thus, for purposes of illustration, Equation (4) can be simplified to (6), if the cyclic variances of each side of the market are assumed to be equal. Because this assumption effectively eliminates errors in supply magnitude, market volatility (variance in vacancy) *depends completely and exclusively on the timing of supply—that is the correlation between completions and absorption*).

$$\sigma^2(V_t - V_{t-1}) = 2\sigma^2(A_t / S_t)[1 - \mathrm{corr}(A_t/S_t, C_t/S_t)]$$
$$\text{with equal variances} \tag{6}$$

In the unlikely situation where supply can respond immediately and so is completely timed with demand, then we have a perfect positive correlation (+1.0) between the two sides of the market, and the right-hand side of (6) collapses to zero. *With high positive correlation—supply* *can totally eliminate or greatly reduce the impact of demand shocks to vacancy.*

When the timing of the supply response is random with respect to demand shocks (a correlation of zero), then the variance in market vacancy is simply the sum of each—or in Equation (6), twice the original variance in demand that is generated by the shocks. It is at this point that supply variance begins to contribute to overall market variance, rather than reducing it. Moving on, as the pattern of supply response generates a negative correlation with demand shocks, supply becomes a serious additional source of market volatility and exacerbates overall vacancy variance. In the extreme case where the supply response results in a perfect negative correlation (–1.0), overall market variance increases to a maximum of four times the original variance from the demand side.

Recapitulating, if both sides of the market have equal variances—with demand coming from shocks while supply results from the response pattern—then market volatility in (6) will range from zero (with perfect positive supply correlation) to 2× demand variance (with zero correlation) on up to 4× demand variance (with perfect negative correlation).

This discussion makes clear what should be examined empirically to analyze the determinants of market volatility. First, examine the variance in vacancy, the correlation coefficient between absorption and completions, and then finally, use the right-hand side of Equation (4) to determine the direction and share that supply contributes to market volatility as opposed to demand. This decomposition is undertaken for four property types using quarterly time series that span approximately 22 years.

DECOMPOSING VOLATILITY IN METROPOLITAN OFFICE MARKETS

The data for the decomposition of office vacancy consist of quarterly time series spanning the years January 1988 through January 2010 from CBRE. The series available are on vacancy, stock, and completions for 51 U.S. metropolitan areas. To avoid confounding seasonal variation with cyclic fluctuations, the calculation of completions, vacancy changes, and absorption are all done on a year-over-year basis. This provides 88 overlapping observations for each metropolitan statistical area (MSA). Exhibit 2 presents for each market the overall variance in vacancy movement, the correlation between

EXHIBIT 2
Office Market Decompositions

MSA	Vacancy Variance	Correlation	Demand %	Supply %
ALBUQU	0.0008	0.017	0.663	0.337
ATLANT	0.0007	0.434	0.896	0.104
AUSTIN	0.0024	–0.161	0.475	0.525
BALTIM	0.0005	0.393	0.721	0.279
BOSTON	0.0008	–0.185	0.579	0.421
CHICAG	0.0004	0.308	0.846	0.154
CHRLTE	0.0008	0.527	0.917	0.083
CINCIN	0.0005	0.507	0.914	0.086
CLEVEL	0.0004	0.343	0.707	0.293
COLUMB	0.0007	0.221	0.527	0.473
DALLAS	0.0006	–0.010	0.528	0.472
DENVER	0.0007	0.033	0.586	0.414
DETROI	0.0005	0.411	0.737	0.263
FORTLA	0.0012	0.083	0.674	0.326
FORTWO	0.0004	0.422	0.956	0.044
HARTFO	0.0009	0.175	0.388	0.612
HONOLU	0.0003	0.890	4.723	–3.723
HOUSTO	0.0005	–0.254	0.603	0.397
INDIAN	0.0005	0.529	0.927	0.073
JACKSO	0.0006	0.526	1.078	–0.078
KANSAS	0.0005	0.273	1.038	–0.038
LANGEL	0.0004	0.448	0.957	0.043
LISLAN	0.0005	0.252	0.542	0.458
LVEGAS	0.0012	0.617	1.208	–0.208
MIAMI	0.0008	–0.226	0.692	0.308
MINNEA	0.0007	0.188	0.641	0.359
NASHVI	0.0006	0.421	0.758	0.242
NEWARK	0.0005	0.478	1.170	–0.170
NEWYRK	0.0004	0.553	1.434	–0.434
OAKLAN	0.0007	0.264	0.923	0.077
ORANGE	0.0009	0.436	0.909	0.091
ORLAND	0.0008	0.643	1.079	–0.079
OXNARD	0.0017	0.137	0.688	0.312
PHILAD	0.0004	0.460	0.943	0.057
PHOENI	0.0013	0.054	0.329	0.671
PORTLA	0.0007	–0.029	0.684	0.316
RIVERS	0.0011	0.831	2.717	–1.717
SACRAM	0.0006	0.676	1.659	–0.659
SALTLA	0.0011	0.251	0.763	0.237
SANTON	0.0006	–0.156	0.659	0.341
SDIEGO	0.0008	0.540	1.037	–0.037
SEATTL	0.0009	0.459	0.846	0.154
SFRANC	0.0013	–0.364	0.591	0.409
SJOSE	0.0022	–0.145	0.538	0.462
SLOUIS	0.0005	0.186	0.596	0.404
STAMFO	0.0007	0.111	0.743	0.257
TAMPA	0.0008	0.320	0.656	0.344
TUCSON	0.0006	0.171	0.750	0.250
WASHIN	0.0005	0.410	0.804	0.196
WBEACH	0.0012	0.030	0.633	0.367
Average	0.0008	0.270	0.909	0.091

the completions and absorption series, and the share of vacancy variance that is due to demand as opposed to supply sides of the market. If the share is multiplied by the variance in vacancy changes (the first column), one gets the demand-side and supply-side contributions on the right-hand side of (4).

In Exhibit 2, the average correlation between the two sides of the office market is significantly positive (0.27), and partially as a consequence, supply accounts for only a small 9% of market volatility. But the averages hide two distinct patterns. First, there are 10 markets (e.g., New York, Riverside) in which the positive correlation between completions and absorption is strong enough (generally greater than 0.50) that the share of market volatility attributable to demand is greater than 1.0. In this case, the supply contribution is actually negative. In these markets, the variance in vacancy would be greater if supply was simply always constant! In other words, supply is actually helping to dampen the impact of demand shocks on overall market volatility. Second, there are 10 markets where the contribution of supply shocks to market volatility is at least 40% or more, and in these markets, the correlation between supply and demand is always less than 0.20—and often negative. These are markets (e.g., San Francisco, Boston) where a largely independent supply variance is contributing quite substantially to overall market volatility.

DECOMPOSING VOLATILITY IN METROPOLITAN HOTEL MARKETS

To examine the hotel market, data were obtained from Smith Travel Research covering a slightly different set of 51 MSAs, over the same period: January 1988 through January 2010. All calculations are done with year-over-year changes so that well-known hotel seasonality does not impact the analysis (Exhibit 3). With this in mind, average hotel vacancy volatility is twice that of offices (0.002 versus 0.001), but the correlation between the two sides of the market is somewhat higher (0.10 versus 0.02). Supply in this sector, on average, has a similarly smaller contribution to overall volatility than in the case of offices: 22% versus 09%. Examining the extremes, as in the case of offices, there are only six markets (e.g., Fort Lauderdale) in which the demand share exceeds one and hence where supply helps to reduce volatility. At the other extreme, there are 20 markets (e.g., Chicago) where the correlation is so low or negative (average 0.03) that the supply side of the market is contributing more than 33% to overall market volatility.

EXHIBIT 3
Hotel Market Decompositions

MSA	Vacancy Variance	Correlation	Demand %	Supply %
ALBUQU	0.0021	–0.129	0.502	0.498
ATLANT	0.0018	0.204	0.953	0.047
AUSTIN	0.0029	0.009	0.628	0.372
BALTIM	0.0014	0.211	0.520	0.480
BOSTON	0.0021	–0.190	0.779	0.221
CHICAG	0.0018	–0.106	0.650	0.350
CHRLTE	0.0030	0.315	0.704	0.296
CINCIN	0.0014	0.164	0.692	0.308
CLEVEL	0.0017	0.033	0.625	0.375
COLUMB	0.0014	0.163	0.739	0.261
COLUSC	0.0027	0.441	0.690	0.310
DALLAS	0.0019	–0.112	0.796	0.204
DAYTON	0.0026	0.343	0.450	0.550
DENVER	0.0015	0.238	0.966	0.034
DETROI	0.0032	–0.160	0.400	0.600
FORTLA	0.0022	0.341	1.075	–0.075
FORTWO	0.0034	0.463	0.732	0.268
HARTFO	0.0025	0.421	0.753	0.247
HONOLU	0.0032	0.178	0.993	0.007
HOUSTO	0.0021	–0.034	0.744	0.256
INDIAN	0.0011	0.419	0.940	0.060
KANSAS	0.0014	0.241	0.776	0.224
LANGEL	0.0020	–0.039	0.746	0.254
LISLAN	0.0033	–0.066	0.390	0.610
MEMPHI	0.0018	0.211	0.798	0.202
MIAMI	0.0027	0.221	0.897	0.103
MINNEA	0.0018	–0.157	0.648	0.352
NASHVI	0.0019	0.479	0.743	0.257
NEWARK	0.0027	0.083	0.498	0.502
NEWORL	0.0030	0.630	1.262	–0.262
NEWYRK	0.0021	0.666	1.370	–0.370
OAKLAN	0.0030	–0.210	0.575	0.425
OMAHA	0.0024	0.228	0.478	0.522
ORANGE	0.0021	0.046	0.625	0.375
ORLAND	0.0025	0.344	1.080	–0.080
PHILAD	0.0015	0.184	0.630	0.370
PHOENI	0.0017	0.289	0.867	0.133
PITTSB	0.0012	0.326	0.910	0.090
PORTLA	0.0018	0.044	0.581	0.419
RALEIG	0.0026	0.288	0.433	0.567
RICHMO	0.0020	0.180	0.660	0.340
SANTON	0.0013	0.501	1.146	–0.146
SDIEGO	0.0019	0.118	0.640	0.360
SEATTL	0.0016	–0.092	0.668	0.332
SFRANC	0.0028	0.025	0.870	0.130
SJOSE	0.0044	0.129	0.833	0.167
SLOUIS	0.0012	0.477	0.912	0.088
TAMPA	0.0008	0.497	1.326	–0.326
TUCSON	0.0015	0.258	0.966	0.034
WASHIN	0.0011	0.032	0.794	0.206
WBEACH	0.0019	0.335	0.832	0.168
Average	0.0021	0.103	0.770	0.230

DECOMPOSING VOLATILITY IN METROPOLITAN APARTMENT MARKETS

In the case of apartments, the data used were from MPF Research, which covered 50 of the same MSAs as the office data, over the identical period: January 1988 through January 2010 (Exhibit 4). In apartments, the average vacancy volatility is tiny relative to the other commercial property types (0.0003 versus 0.001 or 0.002). Partly explaining this, the average correlation

E X H I B I T   4
Apartment Market Decompositions

MSA	Vacancy Variance	Correlation	Demand %	Supply %
ATLANT	0.00029	0.409	0.911	0.089
AUSTIN	0.00041	0.529	1.118	−0.118
BALTIM	0.00025	0.187	1.000	0.000
BOSTON	0.00012	0.252	1.007	−0.007
CHICAG	0.00017	−0.045	0.899	0.101
CHRLTE	0.00038	0.571	1.138	−0.138
CINCIN	0.00034	0.263	1.069	−0.069
CLEVEL	0.00049	0.114	1.009	−0.009
COLUMB	0.00032	0.470	1.275	−0.275
DALLAS	0.00024	0.435	1.147	−0.147
DENVER	0.00032	0.138	0.706	0.294
DETROI	0.00023	0.547	1.395	−0.395
EDISON	0.00013	0.309	1.074	−0.074
FORTLA	0.00027	0.627	1.551	−0.551
FORTWO	0.00022	0.339	1.030	−0.030
HOUSTO	0.00052	0.085	0.881	0.119
INDIAN	0.00045	0.442	1.196	−0.196
JACKSO	0.00046	0.281	0.861	0.139
KANSAS	0.00033	0.445	1.244	−0.244
LANGEL	0.00019	0.374	1.114	−0.114
LOUISV	0.00050	0.122	1.007	−0.007
LVEGAS	0.00035	0.943	9.010	−8.010
MEMPHI	0.00033	0.391	1.121	−0.121
MIAMI	0.00060	0.395	1.180	−0.180
MINNEA	0.00020	0.478	1.291	−0.291
NASHVI	0.00029	0.379	1.060	−0.060
NEWARK	0.00014	0.078	0.974	0.026
NEWYRK	0.00002	0.453	1.174	−0.174
NORFOL	0.00041	0.360	1.149	−0.149
OAKLAN	0.00014	0.647	1.679	−0.679
ORANGE	0.00018	0.730	2.136	−1.136
ORLAND	0.00034	0.772	2.328	−1.328
PHILAD	0.00045	0.004	0.970	0.030
PHOENI	0.00028	0.449	1.186	−0.186
PITTSB	0.00039	0.205	1.040	−0.040
PORTLA	0.00031	0.513	1.227	−0.227
RALEIG	0.00025	0.643	1.489	−0.489
RICHMO	0.00032	0.382	1.150	−0.150
RIVERS	0.00025	0.726	2.033	−1.033
SACRAM	0.00022	0.555	1.418	−0.418
SALTLA	0.00037	0.499	1.252	−0.252
SANTON	0.00028	0.479	1.136	−0.136
SDIEGO	0.00012	0.759	2.356	−1.356
SEATTL	0.00026	0.382	1.029	−0.029
SFRANC	0.00023	0.074	0.980	0.020
SJOSE	0.00038	0.086	0.926	0.074
SLOUIS	0.00078	0.094	0.994	0.006
TAMPA	0.00017	0.630	1.609	−0.609
WASHIN	0.00011	0.261	0.965	0.035
WBEACH	0.00030	0.547	1.422	−0.422
Average	0.00030	0.478	1.378	−0.378

between the two sides of the market is far greater, 0.47 versus 0.26 or 0.10. With this higher correlation, supply in the apartment sector has an average −0.37% contribution to volatility. Again examining the same extreme patterns across markets as with the other property types, in almost 80% of the markets (39), there is a negative contribution of supply to volatility. The correlation between the two sides of the market is so strong and supply volatility small enough relative to demand that supply helps reduce market volatility in the vast majority of markets. At the other extreme, of the 11 markets in which supply exacerbates volatility, the average contribution is less than 10%. The apartment market is far better "coordinated" than the market for hotels or office buildings.

DECOMPOSING VOLATILITY IN METROPOLITAN INDUSTRIAL MARKETS

The industrial market is surprisingly similar to the apartment market—it is very well coordinated. The data here are again from CBRE and covers the same period (January 1988 through January 2010), but in this case, the data span a smaller and different set of only 32 markets (Exhibit 5). The average variation in vacancy changes is 0.00036—very similar to the 0.0003 of apartments and far smaller than for the hotel or office markets. The average correlation between absorption and completions (0.38) is almost as high as apartments, and the average share of volatility due to demand is 1.24%. With this correlation, supply clearly helps to reduce the volatility in the industrial market, by 24%. In 65% of the markets (21), there is a negative contribution of supply to volatility. At the other extreme, of the 11 markets in which supply exacerbates volatility, the average contribution is less than 5%.

CROSS-SECTION ANALYSIS OF DECOMPOSITIONS

A first, and obvious, question that arises is why hotels are so similar to offices and why these two are, in turn, so different from industrial and apartment markets. Because this comparison involves only four data observations, one can only speculate. If land is plentiful, development restrictions few, and building lags short, then in theory, supply should be better "coordinated" with demand. What also might help coordination is the absence of "speculative" development—wherein buildings are constructed without preleasing commitments from tenants. Many industrial buildings for example are "built to suit," where the

EXHIBIT 5
Industrial Market Decompositions

MSA	Vacancy Variance	Correlation	Demand %	Supply %
ATLANT	0.0003	0.525	1.314	–0.314
BALTIM	0.0004	0.513	1.356	–0.356
BOSTON	0.0006	0.155	0.982	0.018
CHICAG	0.0001	0.534	1.381	–0.381
CHRLTE	0.0004	0.416	1.198	–0.198
CINCIN	0.0002	0.456	1.238	–0.238
COLUMB	0.0001	0.472	1.248	–0.248
DALLAS	0.0003	0.286	0.950	0.050
DENVER	0.0003	0.281	0.975	0.025
HARTFO	0.0005	0.309	1.073	–0.073
HOUSTO	0.0003	0.184	0.942	0.058
INDIAN	0.0002	0.418	1.206	–0.206
JACKSO	0.0005	0.159	0.896	0.104
KANSAS	0.0002	0.428	1.224	–0.224
LANGEL	0.0001	0.435	1.170	–0.170
LISLAN	0.0004	–0.049	0.914	0.086
MEMPHI	0.0006	0.609	1.588	–0.588
MIAMI	0.0003	0.351	1.125	–0.125
MINNEA	0.0002	0.619	1.607	–0.607
NASHVI	0.0003	0.303	1.019	–0.019
OAKLAN	0.0004	0.565	1.465	–0.465
ORANGE	0.0003	0.393	1.147	–0.147
PHILAD	0.0003	–0.098	0.822	0.178
PHOENI	0.0006	0.351	0.994	0.006
PORTLA	0.0003	0.567	1.470	–0.470
RIVERS	0.0005	0.886	2.785	–1.785
SDIEGO	0.0002	0.781	2.228	–1.228
SEATTL	0.0002	0.570	1.470	–0.470
SFRANC	0.0004	0.065	0.982	0.018
SJOSE	0.0013	–0.008	0.912	0.088
SLOUIS	0.0002	0.235	1.044	-0.044
WASHIN	0.0004	0.457	0.998	0.002
Average	0.0004	0.380	1.241	-0.241

development is done directly for the buyer/occupier. Similarly, many apartment buildings are developed directly by larger apartment landlords who tend to phase their developments carefully with their perceived market demand.

Within each property type, however, it should be possible to statistically study the variation in coordination and volatility across markets. This effort does not try to make a statement about causal inferences but rather simply tries to identify systematic patterns as to which markets are more volatile, which are better coordinated, and which have a relatively stronger contribution from the demand side of the market as opposed to the supply side. To do this, four cross-section regressions are undertaken. The first is to characterize the correlates of the overall variance in market vacancy. The next two determine how much each correlate impacts the demand as opposed to supply contributions to market volatility. The sum of these impacts equals the coefficient on overall vacancy. The last regression tries to explain the level of coordination (simple correlation) between absorption and completions across the markets. It must be remembered that a positive correlation does not automatically equate to a small (or negative) supply contribution, just like a negative correlation does not automatically generate a large positive contribution. Errors in magnitude as well as timing determine the supply contribution.

As for covariates, seven readily available MSA variables are used. The size and growth rate of a local economy might be expected to impact overall volatility. In Wheaton [1999], real estate stock-flow dynamic models were shown theoretically to be more likely to have internal oscillations when demand growth was rapid. Size is measured with total employment (in 2010) and growth with average annual employment growth rate over the sample period (January 1988–January 2010). With the series on employment, it is possible to calculate the variance in employment growth as a measure of the volatility in the market's underlying economy. It might also be instructive to examine market demographics: average income/worker and the ratio of population/employment (the inverse of labor force participation). These are measured at the end of the sample period (January 2010). Although it is clear that economic volatility should add to the demand-side contribution to real estate variance, it is not easy to identify any priors as to the impact of the other demand-side variables.

There has been considerable discussion about the role that a market's supply elasticity should play in generating long-term price appreciation. In theory, demand fluctuations should also have a more pronounced impact when supply is inelastic—and hence increase volatility. Identifying the covariates of supply elasticity is tricky, however. Mayer and Somerville [2000], for example, argued that larger (monocentric) cities intrinsically have more inelastic land supply. However, there also are two actual metrics of supply restrictions readily available: the Wharton-Lurie [2008] index of procedural restrictions and the Saiz [2010] index of land constraints.

There are four regressions in Exhibit 6 for office properties, and then the same four regressions in Exhibit 7 for apartments. The cross-section analysis was restricted to just these two types of real estate for which

Exhibit 6
Cross-Section Determinants of Office Decompositions

Office Equations	Vacancy Variance	Absorption Variance	Supply Contribution	Correlation
R^2	0.47	0.53	0.29	0.13
Constant	–0.88	–9.2	8.3	2600
	(–0.28)	(2.2)	(1.63)	(0.73)
Employment	–0.00079	–0.00047	–0.00031	0.17
	(–1.6)	(–0.98)	(–0.49)	(0.42)
Emp. Growth	0.71	1.1	–0.31	–280
	(0.97)	(1.43)	(–0.32)	(–0.41)
Emp. Variance	3.1	1.3	1.8	–65
	(3.1)	(1.32)	(1.44)	(–0.07)
Inc/Employment	0.000049	–9300	0.000059	–0.049
	(1.54)	(–.31)	(1.51)	(–1.8)
Pop/Employment	–1.9	5.0	–6.9	2400
	(–1.18)	(3.19)	(–3.54)	(1.73)
WLURI	–0.59	1.6	–2.1	800
	(–0.63)	(1.76)	(–1.91)	(1.02)
Land constraint	2.1	1.9	0.17	–900
	(0.76)	(0.73)	(0.05)	(–0.37)

Notes: All regression coefficients are scaled for presentation purposes. Actual coefficients are reported times 10^{-4}. That is, if one were to use the reported coefficients to calculate the predicted value of the dependent variable, the result would have to be divided by 10,000 to get the actual predicted value. t-statistics are given in parentheses.

Exhibit 7
Cross-Section Determinants of Apartment Decompositions

Apartment Equations	Vacancy Variance	Absorption Variance	Supply Contribution	Correlation
R^2	0.33	0.46	0.44	0.48
Constant	6.4	0.79	5.7	–2200
	(3.66)	(0.18)	(1.23)	(–0.92)
Employment	–0.00040	0.000013	–0.00041	–0.061
	(–1.9)	(0.02)	(–0.81)	(–0.21)
Emp. Growth	–0.12	0.85	–0.97	800
	(–0.85)	(1.17)	(–1.41)	(2.23)
Emp. Variance	–0.14	2.9	–3.0	680
	(–0.39)	(2.91)	(–3.22)	(1.32)
Inc/Employment	–0.000027	–0.000019	–8200	–0.015
	(–1.9)	(–0.45)	(–.21)	(–0.72)
Pop/Employment	0.0091	–1.3	0.14	2100
	(0.02)	(–0.73)	(0.78)	(2.15)
WLURI	–0.57	–2.4	1.8	–390
	(–1.4)	(–2.1)	(1.68)	(–0.65)
Land constraint	0.11	2.1	–1.2	1800
	(1.08)	(0.82)	(–0.41)	(1.31)

the sample of cities is virtually the same. Hotels and industrial properties have very different and differently sized samples, making them not strictly comparable. As previously discussed, offices and apartments also seem to be quite different in their level of coordination and thus may provide an interesting contrast. In each equation, the right-hand-side variables described previously are regressed against the variance in the vacancy rate, the variance in the absorption rate (demand volatility), the correlation-adjusted variance in the completion rate (the supply contribution), and the absolute correlation between completions and absorption.[8] Restricting ourselves to just significant coefficients (at 10%), we begin with a review of how each of our exogenous variables performs across the four components of volatility.

Market size (total employment). Market size has a significant negative impact on overall vacancy volatility for both office and apartment properties but has little impact on how this volatility results. Market size has insignificant affect on demand variance, supply contribution, or market coordination (correlation).

Market employment growth. Faster-growing markets (ceteris paribus) have very little impact on either overall volatility or the breakdown between supply and demand. The only significant coefficient is that for apartment coordination or correlation. Here, faster-growing markets seem to be better coordinated.

Market economic volatility (variance in employment growth). We would expect greater economic volatility to increase demand (absorption) variance, and it does so for both property types, although only in the apartment sector is the effect significant. Interestingly, this variable in the apartment sector also is associated with better coordinated markets with significantly smaller contributions from the supply side.

Market income (average per worker). MSAs with higher wages have less coordination between supply and demand in the office sector, and this tends to increase overall volatility. For apartments, higher-income markets have less overall volatility, but this variable is unimportant in the partition between supply and demand.

Market demographics. Areas with higher population/employment ratios have lower labor force participation, usually from an older population. This has dramatic effects in the office market. Such areas experience much greater demand volatility but also are better coordinated and have much lower supply-side contributions. On net, these offset each other, and there is no significant impact on overall volatility. For apartments, it is just the reverse, but only the level of coordination is significant.

Market regulation (WLURI restrictiveness index). This index is higher for areas with greater surveyed procedural impediments to *residential* development. The areas that have enacted such regulations have lower apartment demand volatility, and the regulations do seem to be associated with a noticeably higher supply contribution. In the office sector, however, the results are just the opposite! Restrictive markets are more volatile on the demand side, with lower contributions from the supply side, possibly due to better coordination. The mixed results of this variable open up the possibility that it is endogenous: markets that have more demand volatility choose to enact greater restrictions (Davidoff [2015]).

Market supply constraints (land *un*availability). This calculated index measures the fraction of total MSA land area which is technically *un*suitable for development (geographically). Areas with greater topographic constraints seem to have no significant effect on either overall volatility or its source. This is true for both office and apartment sectors—there is not one significant impact from greater geographic supply constraints.

The results in Exhibits 6 and 7 can also be examined in terms of what variables significantly impact each of the components of market volatility.

Overall market volatility. Office markets are most volatile in smaller metropolitan areas, with volatile economies and high incomes. Apartment markets are most volatile also in smaller metropolitan areas, but in this case, with lower incomes. Regulatory barriers or supply constraints seem totally unassociated with overall vacancy volatility.

Absorption variance. The variance in net office absorption (demand) is greatest in faster-growing markets, with more-volatile economies, but also in markets with higher population/employment ratios, and greater regulatory barriers (WLURI). Apartment markets also have greater demand volatility when they are smaller, but in this case, also when they have lower regulatory barriers.

Supply contribution. For the office sector, the contribution of the supply side to overall volatility, as determined by Equation (4), is greatest in markets with low population/employment ratios (higher labor force participation) and also markets with lower levels of regulation. For apartments, the supply contribution is greater in market with higher regulatory barriers as well as lower economic volatility.

Market coordination. Office markets are most coordinated (high correlation between demand and supply) when they have lower incomes and higher population/employment. Apartment markets are best coordinated when they have higher population/employment, but in this case, also when they are faster growing.

CONCLUSION

This article presents a simple and deterministic way to decompose the volatility of real estate vacancy into demand and supply "shares." Using 22 years of time series in 50 MSAs and four property types, there are sharp differences between the average decompositions across the property types. The supply contribution to volatility is strong in offices and hotels, while in apartments and industrial buildings, it is negative—supply actually helps offset demand shocks. The supply contribution depends heavily on the magnitude of development booms and their correlation over time with demand. For offices and hotels, the averages (across markets) of the time series correlation between construction rates and absorption rates are 0.02 and 0.10. For apartments and industrials, it is far greater (0.47 and 0.38).

Within property types, there is considerable variation between MSAs. For example, the correlation between supply and demand across apartment markets ranges between 0.07 and 0.77. For offices, the range is between 0.66 and −0.25. Unfortunately, much of this geographic variation is difficult to explain, and what explanations there are can vary sharply between property types. There are cases where an explanatory variable (e.g., economic volatility) has a strong impact on overall vacancy variance (e.g., in offices), but this results evenly from both sides of the market. For apartments, in contrast, the same variable has no overall effect on the volatility, but in this case, it is because although increasing demand volatility, it also is associated with better-coordinated supply.

The most disappointing result concerns the impact of the two variables representing limits on supply. There has been much discussion over the hypothesized impact of such limits on longer-term housing price appreciation, but this article is the first to examine their impact on shorter-term volatility. The WLURI index is supposed to measure regulatory procedures and "delay." This should certainly cause supply to be less coordinated with demand, and this result holds (but insignificantly) in the case of apartments. For offices, however, the opposite result prevails (again with insignificance): more regulated markets have a higher demand/supply correlation. The total supply contribution (taking into account supply variance as well as covariance) is significantly higher in more-regulated apartment markets, but significantly lower in more-regulated office markets. There is little impact of the WLURI index on overall volatility, because areas that have greater regulation can be more or less volatile on the demand side. The presence of greater regulations is associated with greater office demand volatility, but at the same time, it helps coordinate the market, reducing the contribution to volatility from supply. For apartments, greater regulation is associated with low demand volatility but also less coordination and a higher contribution to market risk from supply. The association between demand volatility and the WLURI certainly raises the possibility that greater development regulation is endogenous with respect to market volatility.

The Saiz measure of land *un*availability clearly is exogenous, but there is little evidence that it has any significant impact on either overall real estate market volatility or on the share of volatility coming from either side of the market. This holds for both apartments and office properties.

A final contribution of the study is its revelation that supply can sometimes be viewed as a "friend" to investors. Although more elastic and responsive supply can theoretically limit longer-run rental growth, better coordinated supply will actually dampen market risk in reaction to demand shocks. By stabilizing vacancy, it should also stabilize rental growth. Markets with elastic and quickly responding supply may have less long-run income growth, but they could offer less income risk and hence more stable returns. This has a familiar sound!

ENDNOTES

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[1]See Alberts [1962], Grebler and Burns [1982], and Topel and Rosen [1988].

[2]See Wheaton [1987], Voith and Crone [1988], and King and McCue [1987].

[3]See Kiyotaki and Moore [1997] and Childs, Ott, and Riddiough [1996].

[4]See Harter-Dreiman [2004], Saiz [2010], and Gyourko, Saiz, and Summers [2008].

[5]Capozza, Hendershott, and Mack [2004], Campbell et al. [2009], and Cannon, Miller, and Pandher [2006].

[6]The level of occupancy decomposes linearly as $\log(1 - V_t) = \log(OS_t) - \log(S_t)$.

[7]In this alternative definition $A_t = C_t\,(1 - V_{t-1}) - (V_t - V_{t-1})S_t$. Here, space is assumed delivered at the end of the period fully occupied. In (2) new space is assumed delivered fully occupied at the beginning of the period and then is exposed to whatever change in vacancy occurs in the general stock. As a practical matter the difference in the two is likely to be 0.0001 or less of the stock or 0.01 of any period's typical absorption.

[8]From Equation (4), the coefficient of any variable in the absorption variance equation plus that variable's coefficient in the adjusted-completion contribution equation will equal that in the vacancy variance equation. This relationship does not hold for the standard errors of the variable's coefficients across the three equations.

REFERENCES

Alberts, W.W. "Business Cycles, Residential Construction Cycles, and the Mortgage Market." *Journal of Political Economy*, Vol. 70, No. 1 (1962), pp. 263-281.

Campbell, S., M. Davis, J. Gallin, and R. Martin. "What Moves Housing Markets: A Variance Decomposition of the Price-Rent Ratio." *Journal of Urban Economics,* Vol. 66, No. 2 (2009), pp. 90-102.

Cannon, S., N. Miller, and G. Pandher. "Risk and Return in the U.S. Housing Market: A Cross-Section Asset-Pricing Approach." *Real Estate Economics*, Vol. 34, No. 4, (2006), pp. 519-552.

Case, K., and R. Shiller. "The Efficiency of Market for Single-Family Homes." *American Economic Review*, Vol. 79, No. 1, (1989), pp. 125-137.

Capozza, D., P. Hendershott, and C. Mack. "An Anatomy of Price Dynamics in Illiquid Markets: Analysis and Evidence from Local Housing Markets." *Real Estate Economics*, Vol. 32, No. 1, (2004), pp. 1-21.

Childs, P., S. Ott, and T. Riddiough. "Incomplete Information, Excise Policy and Valuation of Claims on Noisy Real Estate Assets." MIT Center for Real Estate, 1996.

Davidoff, T. "Supply Constraints are Not Valid Instrumental Variables for Home Prices." UBC, Sauder School, 2015.

Grebler, L., and W. Burns. "Construction Cycles in the U.S." *AREUEA Journal,* Vol. 10, No. 2 (1982), pp. 201-222.

Grenadier, S. "Local and National Determinants of Office Vacancies." *Journal of Urban Economics*, Vol. 37, No. 1 (1995), pp. 57-72.

——. "The Persistence of Real Estate Cycles." *Journal of Real Estate Finance and Economics*, Vol. 10, No. 2 (1995), pp. 95-121.

——. "The Strategic Exercise of Options: Development Cascades and Overbuilding in Real Estate Markets." *Journal of Finance*, Vol. 51, No. 5 (1996), pp. 1653-1679.

Gyourko, J., A. Saiz, and A. Summers. "A New Measure of the Local Regulatory Environment for Housing Markets." *Urban Studies*, Vol. 45, No. 3 (2008), pp. 693-729.

Harter-Dreiman, M. "Drawing Inferences about Housing Supply Elasticity from House Price Responses to Income Shocks." *Journal of Urban Economics*, Vol. 55, No. 2 (2004), pp. 316-337.

King, J., and T. McCue. "Office Building Investment and the Macroeconomy." *Real Estate Economics*, Vol. 15, No. 3 (1987), pp. 234-255.

Kiyotaki, N., and J. Moore. "Credit Cycles." *Journal of Political Economy*, Vol. 105, No. 2 (1997), pp. 211-248.

Mankiw, G., and D. Weil. "The Baby Boom, the Baby Bust, and the Housing Market." *Regional Science and Urban Economics*, Vol. 19, No. 2, (1989), pp. 235-258.

Mayer, C., and T. Somerville. "Residential Construction: Using the Urban Growth Model to Estimate Housing Supply." *Journal of Urban Economics*, Vol. 48, No. 5 (2000), pp. 85-109.

Poterba, J.M. "Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach." *Quarterly Journal of Economics*, Vol. 99, No. 4 (1984), pp. 729-752.

Rosen, K., and L. Smith. "The Price Adjustment Process for Rental Housing and the Natural Vacancy Rate." *American Economic Review*, Vol. 73, No. 1 (1983), pp. 779-786.

Saiz, A. "The Geographic Determinants of Housing Supply." *Quarterly Journal of Economics*, Vol. 100, No. 3 (2010), pp. 500-530.

Stein, J. "Prices and Trading Volume in the Housing Market: A Model with Down Payment Effects." *Quarterly Journal of Economics*, Vol. 110, No. 2 (1995), pp. 379-406.

Topel, R., and S. Rosen. "Housing Investment in the United States." *Journal of Political Economy*, Vol. 96, No. 3 (1988), pp. 718-740.

Voith, R., and T. Crone. "National Vacancy Rates and the Persistence of Shocks in U.S. Office Markets." *AREUEA Journal*, Vol. 16, No. 4 (1988), pp. 437-458.

Wheaton, W. "The Cyclic Behavior of the National Office Market." *Real Estate Economics*, Vol. 15, No. 4 (1987), pp. 281-289.

——. "Real Estate Cycles: Some Fundamentals." *Real Estate Economics*, Vol. 27, No. 2, (1999), pp. 209-231.