Property Mix Heterogeneity and Market Cycles: How Much Can We Rely on Median-Price Indices?

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ABSTRACT

Objective. Understand in which types of location median-price indices could provide reasonable estimates of rent growth. As far as our research allows, the market-based measures developed throughout this study are the first to emphasize office properties in Brazil using an hedonic framework.

Methodology. Create appraisal-based indices of rent growth using median-price and hedonic-based techniques for two regions with different degrees of property mix heterogeneity and compare their behavior overtime.

Findings. Volatility in median-price measures is larger than hedonic-based measures in market peaks and troughs due to different weighting of high and low-tier properties overtime. This result is stronger in the location with higher property mix heterogeneity and, consequently, exacerbates market cycles in this region.

Limitations. We do not find statistically significant differences between the measures considered. Nevertheless, we do not consider whether this similarity would hold when using transactional-based data.

Originality/Value. Our results suggest that researchers, policy makers and investors need to take into account the “undesired fluctuation” of median-price measures when interpreting such indices.

KEYWORDS: commercial real estate, office properties, indices, Brazil.

1 Motivation and Background

Understanding future patterns of income growth such as rent prices is central to real estate investors and policy makers. In commercial real estate, there is a long established literature on hedonic indices as a mean to create reasonable measures of profitability that controls for both locational and physical characteristics of office properties. Following our motivation to deploy a measure of rent growth which is consistent and relatively easy to be understood and implemented, we use the quintessential log-linear time dummy method to construct stratified median-price and hedonic indices for two regions of Sao
Paulo: Centro and Faria Lima/Itaim. As far as our research allows, this is the first attempt to create hedonic rent indices specifically designed for office markets in Brazil.

The quest to develop robust market-based measures of returns gained ground in Brazil after the large swing on real estate prices in the last few years. When it comes to the residential real estate market, the Residential FIPE-ZAP rent indices, published through a partnership between Fundação Instituto de Pesquisas Economicas (FIPE) and ZAP Imóveis (ZAP), were pioneers in the country. The city level FIPE-ZAP index is obtained through aggregation of median-price indices of census districts (Fipezap, 2014). Additionally, Secovi (2015) also developed a similar measure for apartments in Sao Paulo; however, this institution reports income growth in different neighborhoods instead of a city-wide measure. As far as our research allows, the IGMI-C rent index, published by Fundacao Getulio Vargas, is one of the only measures of rent returns for commercial real estate (CRE). Data for all CRE markets in the entire country, including warehouses, shopping malls, hotels and office properties, is obtained through surveys with a handful of institutional investors. In Q2:2015, FGV obtained data from 525 properties to compute the IGMI-C. FIPE and ZAP also launched CRE indicators which use the same methodology as residential FIPE-ZAP.

The appeal of median-price indices lies in computational simplicity. Nevertheless, they also provide poor estimates of short term changes in rent as they reflect shifts in the composition of the sample. Ghysels, Plazzi, Valkanov, & Torous (2013, p.520) point out that it is “reasonable to expect the mix of homes sold to be correlated with local economic conditions as more expensive homes will tend to be put on the market in expansionary times.” Therefore, median-price indices provide “not only a noisy but also a systematically biased estimate of the behavior of […] prices in a particular market”. Prasad & Richards (2008) show that it is possible to maintain the quality of median-price indices constant in a novel stratification method using data from the six largest cities in Australia. These authors grouped locations based on the long-run average prices of dwellings in those cities instead of clustering smaller regions into larger areas. This stratification setting was specifically designed to control for compositional changes in the strata. The authors come to this conclusion by comparing the behavior of stratified median-price indices with regression-based measures, such as hedonic and repeat-sales. While their aggregate median-price indices may be statistically consistent, their disaggregate measures are not very appealing as practitioners are often concerned with price changes in specific regions.

Our research contributes to the CRE literature as we test whether stratified median-price indices of rent growth can be applied in regions with relatively homogeneous property-specific quality. To do this we selected two locations of
Sao Paulo, namely Faria Lima/Itaim, and Centro, and compared the behavior of the stratified median-price index with hedonic-based measures as in Prasad & Richards (2008). We selected these regions based on asset quality heterogeneity, with Centro holding a more similar mix of office properties than Faria Lima/Itaim.

The results indicate that even when we control for location through stratification, the consistency of median price estimates still depends on property mix heterogeneity in a given region. For instance, our median-price (MP) index is fairly consistent with hedonic-based measures in Centro, but not in Faria Lima/Itaim. These findings suggest that MP peaks and troughs in Faria Lima/Itaim are exacerbated due to changes in the weights of high- and low-tier buildings throughout the market cycle. One logical solution for this issue would be to define the strata according to different locations and property-specific characteristics. Nonetheless, stratification can become intractable and subjective as several characteristics can be considered (e.g. Fenwick, 2013 and Fipezap, 2014). Another possible alternative is to use hedonic-based techniques as suggested by Hill, Melser, & Syed (2009), Dorsey, Hu, Mayer, & Wang (2010) and Hill (2011) at least as a back test for consistency of median-price estimates.

The paper is structured as follows: section 2 describes the methodologies and variables used to compute the median-price and hedonic-based indices, section 3 reports the results and compares the estimates, and section 4 concludes.

2 Empirical Model

There is a long established literature on real estate indices which shows that each methodology has pros and cons. As mentioned previously, the primary advantage of median-price indices is computational simplicity. The main issue of this type of measure is the lack of control for compositional changes in the sample.

The second simplest alternative to this approach are time dummy hedonic indices. The primary strength of the hedonic methodology is that it utilizes a cross section of locational and property-specific data to limit noise in the index. This alternative; however, requires data to be “flush, robust and extensive in measuring heterogeneity between and within a building” (Chegut, Eichholtz, & Rodrigues, 2013). Yet such data is often not available to the general public and researchers. For a deeper understanding of hedonic models see Hill (2011).

2.1 Identification Strategy

First, we stratify the data at regional level to estimate the standard time-dummy method. This setting relaxes the assumption of similar valuation of a given characteristic across different regions (Fenwick, 2013) and diminishes the need...
to control for location (Rosen, 1984, Webb & Fisher, 1996, and Gunnelin & Söderberg, 2003). The model takes the following form:

\[ P_{it} = \beta_c C_{ci} + \tau_t Q_{it} + \epsilon_{it}, \] (1)

where \( P_{it} \) is the natural logarithm of asked rent per square foot of property \( i \) located in a given region at time \( t \) and \( C_{ci} \) is a vector of observable asset-specific characteristics \( c \) for property \( i \). The term \( Q_{it} \), is a \( T \times (Q_{it} - 1) \) matrix of dummy variables, \( \tau_t \) is a \( (Q_{it} - 1) \times 1 \) vector of submarket-period parameters and \( Q \) is the number of quarters. As common practice in the application of the time dummy method, we set \( Q_{i1} \) equal to zero so that \( \tau_t \) captures all time varying shifts in the hedonic surface as compared to the surface of the first quarter.

The second model contains zip-code identifiers as in Hill et al. (2009) and Campbell, Giglio, & Pathak (2011). The motivation behind this additional term is that traditional determinants of rent are often not sufficient to account for spatial variation. Hence, there may still be a concern with unobserved heterogeneity, both locational and property-specific, and data censoring at micro level (Ghysels et al., 2013). Hill et al. (2009) also found that this approach can substantially improve the predictive power of hedonic regressions. The extension of equation (1) takes the following form:

\[ P_{it} = \beta_c C_{ci} + \phi_i D_i + \tau_t Q_{it} + \epsilon_{it}. \] (2)

The additional term \( D_i \) is an \( A \times (Z - i - 1) \) matrix of dummy variables, \( \phi \) is a \( (M - 1) \times 1 \) vector of parameters and \( Z \) is the number of zipcode identifiers. Note that \( D_i \) captures all variation associated with location and unobserved asset-specific features which do not change overtime. Note that any time-unvarying characteristic from \( C_{ci} \) is dropped from (2) due to perfect multicollinearity with the fixed effects.

The methodology used for our third and final model is analogous to that of a median-price index. We consider a time-dummy regression as in the previous cases, but we do not include locational or property-specific control variables. The advantage of this approach relative to a straightforward average is that we are able to obtain the standard errors of our median-price index. Such measure is computed as follows for a given region:

\[ P_{it} = \tau_t Q_{it} + \epsilon_{it}. \] (3)

If median-price indices are similar to hedonic-based measures, then the estimates \( \tau_t \) for models (1), (2) and (3) would yield similar outcomes as in Prasad & Richards (2008).
### 2.2 Data

The data for office properties used in our estimates were manually extracted from CRE Tool, an up-to-date system that offers an extensive appraisal dataset for commercial real estate in Brazil. This dataset was created by Buildings, a company solely specialized in real estate research. The sample of office properties spans from 2005:Q3 to 2014:Q3 on a quarterly basis.

We stratified the regions of Faria Lima/Itaim and Centro according to the boundaries defined by Buildings. According to Bourassa, Hoesli, & Peng (2003) and Chen, Cho, Poudyal, & Roberts (2009) submarket perimeters drawn using a priori information from experts have better in-sample performance than other types of regional clustering.

The literature on determinants of rent is long established. Many authors confirm the role of physical depreciation (Clapp, 1980; Bollinger, Ihlanfeldt, & Bowes, 1998; Slade, 2000; Dunse, Leishman, & Watkins, 2002), building size (Clapp, 1980; Glascock, Jahanian, & Sirmans, 1990; Bollinger et al., 1998) and vacancy rates (Glascock et al., 1990; Pollakowski, Wachter, & Lynford, 1992; Hendershot, MacGregor, & White, 2002) in their empirical estimates of real estate income and prices. The inclusion—and significance—of these variables as well as building class scales in hedonic models is confirmed in recent research from Eichholtz, Kok, & Quigley (2010), Brounen & Kok (2011), Fuerst & McAllister (2011), Reichardt, Fuerst, Rottke, & Zietz (2012), and Fuerst, McAllister, & Sivitanides (2015). Whenever possible, we include the variables from Table 1 in our estimates of (1) and (2).

The descriptive statistics in Table 2 reinforce the relevance of controlling for location and asset-specific characteristics in our estimates. The sample of properties in Faria Lima/Itaim region consists of newer and upper class properties when compared to Centro. For instance, 14.2% of the buildings in Faria Lima/Itaim are A-rated properties and 30.1% are less than ten years old. At the same time, Centro holds a largest proportion of low tier and older properties. C-class buildings and properties that have been renovated more than 30 ago represent, respectively, 84.4% and 86.4% of the sample of this region.

Some stylized facts about Sao Paulo can explain the discrepancies in property mix heterogeneity in these locations. Many buildings in Centro face historical preservation issues and zoning restrictions limit the development new commercial towers or refurbishment of the existing ones. In contrast, Faria Lima/Itaim region has been exposed to rapid growth since 1970s and, consequently, holds a fairly heterogeneous property mix, with older buildings from the first waves and newer top-tier properties used by financial institutions and larger companies.
Table 1: Description of Variables.

| Variable | Description |
|----------|-------------|
| Income   | The natural logarithm of nominal asked rent per square foot. |
| Rating   | A dummy to capture each building class (standard categories AAA, AA, A, BB, B and C). Buildings classifies Rating based on objective (i.e. gross leasable area, floor area, size and age) and subjective (i.e. current occupation, corporate image and quality of technical specifications) characteristics of each asset. This variable is set to one when an asset belongs to a certain class at a given period of time and zero otherwise. All C class buildings were set to zero to avoid perfect multicollinearity. Thus all other classes are measured as premiums relative to this class. |
| Age      | Measured from the year of construction or the year of a major refurbishment (whichever occurred more recently). Observations for building age were segmented into thresholds to allow for potentially time-varying age effects. If a building belongs to a certain age group, this variable takes the value of one and zero otherwise. All assets that are less than 4 years old were set to zero to avoid perfect multicollinearity. Hence parameters for all age thresholds represent discounts relative to new assets. |
| Size     | The natural logarithm of the gross leasable area measured in squared meters. |
| VacPerc  | The percentage of vacancy relative to the gross leasable area multiplied by one hundred. |

3 Results

We report the estimates of equations (1), (2) and (3) for Centro and Faria Lima/Itaim in Table 3. In order to simplify the technical jargon regarding the methodologies, we denominate each equation, respectively, as pooled OLS (POLS), zip-code level fixed effects (FE), and median-price (MP) hereinafter. Following Eichholtz et al. (2010), the standard errors for all estimates are heteroskedasticity robust as in White (1980).

Consistent with Hill et al. (2009), we also find that zip-code level fixed effects add explanatory power to the FE model in all regions. In Centro, for instance, the R-squared of FE, POLS and MP were 0.58, 0.51 and 0.43, respectively. The FE index also has the lowest standard errors. We also run alternative regressions with vanilla standard errors and find similar results. These findings reinforce that stratification at regional level is insufficient to control for spatial variation and unobserved property-specific characteristics (e.g. Ghysels et al., 2013,
**Table 2: Summary Statistics of Variables**

*Income:* the asked rent per square meter of a given property. *Age:* measured from the year of construction or the year of a major refurbishment (whichever occurred more recently). *Size:* gross leasable area measured in squared meters. *Rating:* a dummy for each building class (standard categories AA, AA, A, BB, B, and C). *VacPerc:* the percentage of vacancy relative to the gross leasable area multiplied by one hundred.

| Variable     | Faria Lima/Itaim | Centro                        |
|--------------|------------------|-------------------------------|
| **Mean**     | **Std. Dev.**    | **Min** | **Max** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| Income       | 58.62            | 37.19  | 10      | 220      | 18.75         | 13.16  | 5       | 126      |
| Size         | 5,511.49         | 4,834.79 | 440    | 34,911.73 | 5,895.22     | 7,438.6 | 400    | 46,500.00 |
| VacPerc      | 12.845           | 21.395 | 0.18    | 100      | 17.52         | 34.19  | 0.07   | 100      |
| **Building Class** |                |        |         |          |               |        |        |          |
| AAA          | 0.011            |        |         | 0.00     |               |        |        |          |
| AA           | 0.036            |        |         | 0.00     |               |        |        |          |
| A            | 0.095            |        |         | 0.002    |               |        |        |          |
| BB           | 0.074            |        |         | 0.055    |               |        |        |          |
| B            | 0.415            |        |         | 0.100    |               |        |        |          |
| C            | 0.370            |        |         | 0.844    |               |        |        |          |
| **Age**      |                  |        |         |          |               |        |        |          |
| 0to3         | 0.103            |        |         | 0.016    |               |        |        |          |
| 4to6         | 0.071            |        |         | 0.002    |               |        |        |          |
| 7to10        | 0.127            |        |         | 0.008    |               |        |        |          |
| 11to15       | 0.173            |        |         | 0.019    |               |        |        |          |
| 16to20       | 0.101            |        |         | 0.024    |               |        |        |          |
| 21to25       | 0.078            |        |         | 0.022    |               |        |        |          |
| 26to30       | 0.079            |        |         | 0.045    |               |        |        |          |
| 31plus       | 0.268            |        |         | 0.864    |               |        |        |          |
| **Obs**      | 3790             |        |         |          |               |        |        |          |
| **N Buildings** |                |        |         |          |               |        |        |          |

At a glance it is possible to observe that the indices for each region are generally similar regardless of the methodology adopted. Between 2005:Q3 and 2014:Q3 the estimates of POLS, FE and MP indicate that rent from properties located in Faria Lima/Itaim increased 105.4%, 98.3% and 97.7%, respectively, prior to exponentiation. When we convert these numbers into percent changes they become 186.9%, 167.2% and 165.6%. The same figures in Centro were 99.2%, 92.6% and 100.9% (183.4%, 167.2% and 186.3% after exponentiation). The statistical difference between the estimates for each location is insignificant. Nevertheless, the standard deviation of MP is often higher than that of POLS and FE, indicating that excess volatility in MP is likely to be associated with shifts in the property mix. These results are emphasized in Figure 1, where we show selected parameters of Table 3.

Albeit the positive correlation and statistical similarity between the indices, the undesired additional volatility related to asset quality in MP can be misleading to investors, especially if the concern is with the overall cyclicality in real
Table 3: Regression Estimates of Ln(UNICONE/£M)
This figure reports selected parameters and standard errors from regressions on Table 3. POLS, FE, and MP are, respectively, estimates of equations (1), (2) and (3) for each region. These numbers are reported prior to exponentiation. Standard errors are heteroskedacity robust as in White (1980).

Figure 2 shows that mean MP peaks and troughs are generally larger than that and of FE in Faria Lima/Itaim while POLS stands somewhere in between. For instance, MP after exponentiation indicates that year-on-year (YoY) rent growth in Faria Lima/Itaim reached 56.1% when the market peaked in 2012:Q1. The same figures for POLS and FE were, respectively, 42.4% and 37.0%. At the same time, the indices moved fairly close together when we consider Centro. These results suggest that undesired volatility of MP tends to be higher in locations where property heterogeneity is larger and, thus, where office properties with different characteristics are more likely to be put in the market at different times (e.g. Ghysels et al., 2013, Hill, 2011, and Prasad & Richards, 2008). These results are particularly relevant as
Figure 2: NOMINAL YEAR-ON-YEAR GROWTH OF INCOME/SQM
This figure reports year-on-year variation of selected parameters from the regressions on Table 3 after exponentiation. POLS, FE, and MP are estimates of equation (1), (2) and (3) for each region, respectively.

these two regions are major office market locations in Sao Paulo.

In regions with higher property mix heterogeneity, it is not surprising to see exacerbated volatility in MP estimates. During “boom” periods newer buildings are put into the market and the weight of these properties in a given region increases (Ghysels et al., 2013). In recessionary times, tenants gain bargaining power over landlords, property attributes are priced significantly differently than in normal periods (Slade, 2000) and the price premium between high and low-quality properties increases due to illiquidity among low-tier buildings (Fuerst et al., 2015). It is plausible to think that the flight-to-quality phenomenon is due to a change in weighting towards lower quality properties as these are more prone to be vacant during a crisis.

It is worth noting that our rent growth indices consider asking rents instead of actual rents. Fuerst (2008) emphasizes that the difference between
these measures tend to be larger in peaks and troughs of market cycles. For instance, landlords usually provide discounts and other incentives to tenants in recessionary periods instead of lowering asking rents. This later fact is consistent with our estimates. We find that nominal income growth is very close to zero between 2013:Q1 and 2014:Q3 (Figure 2). Chegut et al. (2013), Fisher, Gatzlaff, Geltner, & Haurin (2003), and Geltner & Pollakowski (2007) show that transaction-based indices can be substantially more volatile than appraisal-based measures in developed economies. The statistical similarity between our median-price and hedonic-based indices may not necessarily hold if we use transactional-based data. Unfortunately, we do not have such data available to further analyze the issue.

4 Concluding Remarks

There is little doubt about the importance of market-based measures of profitability in real estate. In light of this scenario we develop appraisal-based income indices specifically focused in Brazilian office properties. The techniques adopted are consistent with past research and relatively easy to be understood and implemented.

Our research contributes to the existing commercial real estate literature as we compare different techniques, namely stratified median-price and hedonic-based measures, in two regions with different levels of property mix heterogeneity. The results suggest that median-price indices have higher volatility than hedonic measures in market peaks and troughs due to different weighting of high and low-tier properties overtime. Our findings are stronger in the location with a more heterogeneous property mix and, consequently, exacerbate market cycles in this region. Such undesired additional volatility related to asset quality can be misleading to investors, especially if the concern is with the overall cyclicality in real estate markets (Bianconi & Yoshino, 2013).

These results indicate that researchers, policy makers and investors should take into account this potential bias when interpreting median-price indices. One potential solution for this issue would be to define the strata according to different locations and property-specific characteristics. Nevertheless, stratification may become difficult to handle as several characteristics could be considered (e.g. Fenwick, 2013 and Fipezap, 2014). Another possible solution is to use hedonic-based techniques as suggested by Hill et al. (2009), Dorsey et al. (2010), and Hill (2011), at least as a back test for consistency of median-price estimates. We do not test whether our findings are valid with transactional-based data or in other locations. Nevertheless, evidence from developed economies suggests that transactional-based indices are generally more volatile than appraisal-based measures (e.g. Chegut et al., 2013, Fisher et al., 2003, and Geltner & Pollakowski, 2007). This could be an opportunity for future research when transactional-based data is available.
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