STREETSINE SINGAPORE PTE. LTD.
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THE SINGAPORE REAL ESTATE EXCHANGE PROPERTY INDEX [SPI] WHITE PAPER

Hedonic Property Price Indices for Singapore Private Residential and Public Housing Properties

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1. Introduction

1.1. An overview of the SPI

The Singapore Real Estate Exchange Property Index [SPI] is a transaction-based index that monitors the month-on-month sales and rental price movements of residential properties in Singapore. The basket of indices covers both the private and public housing markets.

The rationale behind creating the SPI is multiple-fold. First, the SPI provides a real-time reference index for real estate professionals and the public to monitor the price changes in the property market, enhancing the efficiency of property price information distribution in Singapore.

Second, the SPI tracks price performances across several property sub-markets, so as to provide a robust platform for managing risks and returns in investment portfolios.

Third, the SPI compliments existing property information and indices on the state of the Singapore residential market by publishing information on rental prices.

Fourth, the SPI standardizes the methodology to monitor prices in both private and public housing markets, leading to easier cross-comparisons between the two market segments.

StreetSine Singapore Pte. Ltd. developed the SPI as part of its role as the architect of Singapore Real Estate Exchange [SRX] – an information consortium formed by leading estate agency companies in Singapore to share proprietary sales and rental data. StreetSine computes the data based on the transacted prices of all available property transaction information, including caveat information from URA and and non-caveated sales and rental information from agencies' proprietary transaction data. (Note that we have excluded bulk purchases, *en bloc* transactions and executive condominium transactions for private non-landed indices. For HDB indices, we excluded one and two-room flats.)

The computation of the SPI employs three sets of data:

(i) Project data, such as geospatial coordinates, project completion (TOP) date, land tenure, and distance of all the individual dwelling units in these projects to amenities (e.g., MRT and top primary schools);
(ii) SRX transaction data, including transacted price, date of contract, size, and floor level information for both sale and rental transactions of private and HDB units;
(iii) URA transaction data, including transacted price, date of contract, size, and floor level information to complement SRX private sale transactions.

Using hedonic regression methodology, StreetSine computes the SPI based on the coefficients attached to periodic dummy variables defined in section 2.2.2. Holding constant the property characteristics (e.g., size, floor level, location, etc.) that could impact

price, SPI methodology uses the coefficients attached to each periodic dummy variable to deduce the percentage property price change with respect to the base period. For each region's sub-index, the algorithm selects the corresponding sub-samples from the transaction population and then computes the appropriate sub-index values using the same regression model.

1.2. Differences between SPI and other property price indices in Singapore

SPI differs from other Singapore indices in four distinct ways:

(i) SPI is the first index to calculate price changes that take into account unique Singaporean factors such as the property's distance to a top primary school or an MRT station. The index, of course, controls for standard index factors like location, age of property, size, floor levels and land tenure;

(ii) SPI uses a Hedonic Regression methodology modeled on proven real estate economics and consumer price indices worldwide;

(iii) SPI employs unique data available only to SRX. As a result, for private sale transactions, the indices include both public caveated transactions and non-caveated transactions, resulting in a comprehensive view of the property market at any point in time;

(iv) Due to its industry-wide integration with the market's major estate agencies StreetSine, on behalf of SRX, collects, processes, integrates and crunches data in real-time. Hence, StreetSine can calculate and release monthly SPI updates before other Singaporean indices.

1.3. The flash and revised SPI values

The flash SPI for month *t* is computed on the Wednesday of the first complete week into month *t*+1 (Monday is counted as the first day of a week), and published on the Friday of the same week. A revised estimate of the SPI for month *t* will be computed in month *t*+2 using the same cut-off date rule. Using April 2013's SPI as an example, the flash SPI was computed on 8th May and published on 10th May. The revised April SPI was computed on 5th June and published on 7th June.

Due to the real-time nature of SRX transaction data, the flash SPI published in month *t*+1 has already captured the vast majority of market transactions in month *t*. Thus, any updates to the SPI values will be minor when compared with that of indices that use only public transactions.

1.4. The outline of the SPI White Paper

Section 2 describes the SPI methodology, including its key features and the computation procedure. Section 3 showcases the various sub-indices included in the SPI.

1.5. Comments on the SPI

StreetSine and SRX invite comments on SPI. If you have any questions or comments, please write us at info@srx.com.sg.

2. The SPI Methodology

2.1. Key features

StreetSine constructed SPI using a proven hedonic price method. The real estate market is heterogeneous. Each dwelling unit has a unique set of characteristics. Thus, it is crucial that property price indices take into account these quality differences. Hedonic methods, which express home prices as a vector function of property characteristics, are particularly useful for this purpose. Apart from including standard characteristics used in most hedonic pricing models (such as land tenure, location, age of property, size and floor level), the SPI also controls characteristics that are unique to the Singapore real estate market, such as whether the unit sits on the top floor or the first floor, distance to MRT stations, and distance to the top primary schools.

Second, the SPI allows for changes to the characteristics over time. For example, it factors in announcements and openings of new MRT lines and stations. Such control variables add dynamism to the conventional hedonic model and ensure that prices for each time period are compared on a fair and standardized basis.

For the purpose of this paper, non-landed private residential resale index is used as the main example in the discussion that follows.

2.2. The SPI computation procedure

The SPI computation procedure can be summarized into three stages:

- Hedonic equation modelling;
- Assigning values to each variable; and
- Computing index values from time dummy coefficients.

2.2.1. Hedonic Equation Modelling

The modelled characteristics which affect Singapore's non-landed private residential unit resale prices (PSF) are listed below:

(i) Location [in terms of districts]

(ii) Land Tenure

(iii) Property age

(iv) Strata-title area

(v) Floor Level

(vi) Distance to MRT stations

(vii) Proximity to top primary schools, for admission purposes

(viii) Top Floor

(ix) First Floor

(x) Time [in terms of monthly periods]

2.2.2. Variable Definition

In order to perform hedonic computations, each characteristic mentioned in 2.2.1 should carry a quantifiable value. In other words, each characteristic needs to be transformed into variable(s).

The variables are defined into three broad categories. Strata-title area, unit resale price, and distance to MRT stations are continuous quantities or continuous variables, which can carry infinite numbers of real values, such as strata-title area of 800.5 square feet, unit resale price of $1,000.999psf, and distance to MRT of 300.2 meters.

The second category is discrete variables. Property age, Floor Level are examples of discrete variables because they can only take finite countable values, such as a property of 5 years' old and sits on the 2nd floor.

The third category is dummy variables. These variables take values of either 0 or 1 to indicate the absence or presence of certain categorical effect. The values of some characteristics cannot be arranged in meaningful orders. For example, District 11 homes do not necessarily command higher or lower prices than those in District 10, even though the number 11 has a bigger numeric value than 10. Each district carries distinctive effects on home prices, but the effects are not ordinal. As a result, 27 dummy variables (District 2 to District 28) have to be designed to control for the different effects of 28 districts in Singapore. For a transaction in District 2, the District 2 dummy takes a value of '1', the other dummies are left with input '0'. Intuitively, District 1 transactions have inputs of '0' for all 27 district dummies. Location, land tenure, proximity to top primary schools, top floor, first floor, and monthly periods are those characteristics falling into this category.

Thus, the equation to relate unit resale price and these characteristics are as follows

$$Price_{PSF} = [Tenure^{\alpha_1} Age^{\alpha_2} Size^{\alpha_3} Floor^{\alpha_4} MRT^{\alpha_5} School^{\alpha_6}] \cdot e^{\alpha_7 Top} \cdot e^{\alpha_8 First} \cdot e^{\alpha_9 D2 + \alpha_{10} D3 + \alpha_{11} D4 + \cdots + \alpha_{35} D28} \cdot e^{\beta_1 T1 + \beta_2 T2 + \beta_3 T3 + \cdots + \beta_n Tn}$$

The equivalent linear equation is

$$\begin{aligned} &\log(Price_{PSF}) \\ &\quad = \alpha_1 \log(\text{Tenure}) + \alpha_2 \log(Age) + \alpha_3 \log(Size) \\ &\quad + \alpha_4 \log(Floor) + \alpha_5 \log(MRT) + \alpha_6 (School) + \alpha_7 Top \\ &\quad + \alpha_8 First + [\alpha_9 D2 + \alpha_{10} D3 + \alpha_{11} D4 + \cdots + \alpha_{35} D28] + [\beta_1 T_1 \\ &\quad + \beta_2 T_2 + \beta_3 T_3 + \cdots + \beta_n T_n] \end{aligned}$$

Where

Price$_{PSF}$ = Continuous variable of transacted price divided by floor area (sq ft).

Land Tenure = Single dummy variable, taking value of 1 if the property belongs to freehold or 999-year leasehold tenure, taking value of 0 if the property belongs to 99-year leasehold tenure.

Age = Discrete variable of property age with respect to its completion [TOP] date, taking finite integer values.

Size = Continuous variable, the strata-title area of the subject property.

Floor = Discrete variable of the floor number which the subject property sits on, taking finite integer values.

MRT = Continuous variable of distance to the closest MRT/LRT stations.

School = Single dummy variable, taking value of 1 if the property is within one kilometre from the top-ten ranking primary schools, 0 otherwise. The existing Ministry of Education policy states that kids from families who stay within 1km from a particular school have priority admission advantages.

Top = Single dummy variable, taking value of 1 if the subject home sits on the top floor of the building, 0 otherwise. Penthouses are usually found on the top floor. The lower ratio of effective liveable space, a common characteristic attached to the penthouses, has a unique effect on prices.

First = Single dummy variable, taking value of 1 if the subject home sits on the first floor, 0 otherwise. Sitting on the first floor could provide convenience and accessibility to facilities and thus, attracting a certain group of buyers to pay a premium for it.

D2 to **D28** = District dummy variables, representing District 2 to District 28. A district variable takes value of 1 if a subject property belongs to that particular district, 0 otherwise.

T_1 to **T_n** = Monthly period dummy variable, representing the time period n month from the base period. In this hedonic regression model, January of 2009 is defined as the base period. Hence T_1 represents February of 2009, so on and so forth.

For each new month, one more month dummy is to be injected into the model.

2.2.3. Computing index values from time dummy coefficients

After running the regression analysis, the value set of β_1 to β_n constants can be retrieved from the output.

The price in the base period can be expressed as:

$P_0 = \vartheta e^0$ where ϑ captures the other assumed property attributes in a standardized form.

Likewise, the price in each other time period can be expressed as:

$P_1 = \vartheta e^{\beta 1}$; $P_2 = \vartheta e^{\beta 2}$; $P_3 = \vartheta e^{\beta 3}$;...$P_n = \vartheta e^{\beta n}$;

Hence, the price ratios between these following periods and the base period are:

$$\frac{P_1}{P_0} = e^{\beta_1};$$

$$\frac{P_2}{P_0} = e^{\beta_2};$$

$$\frac{P_3}{P_0} = e^{\beta_3};$$

...

$$\frac{P_n}{P_0} = e^{\beta_n}.$$

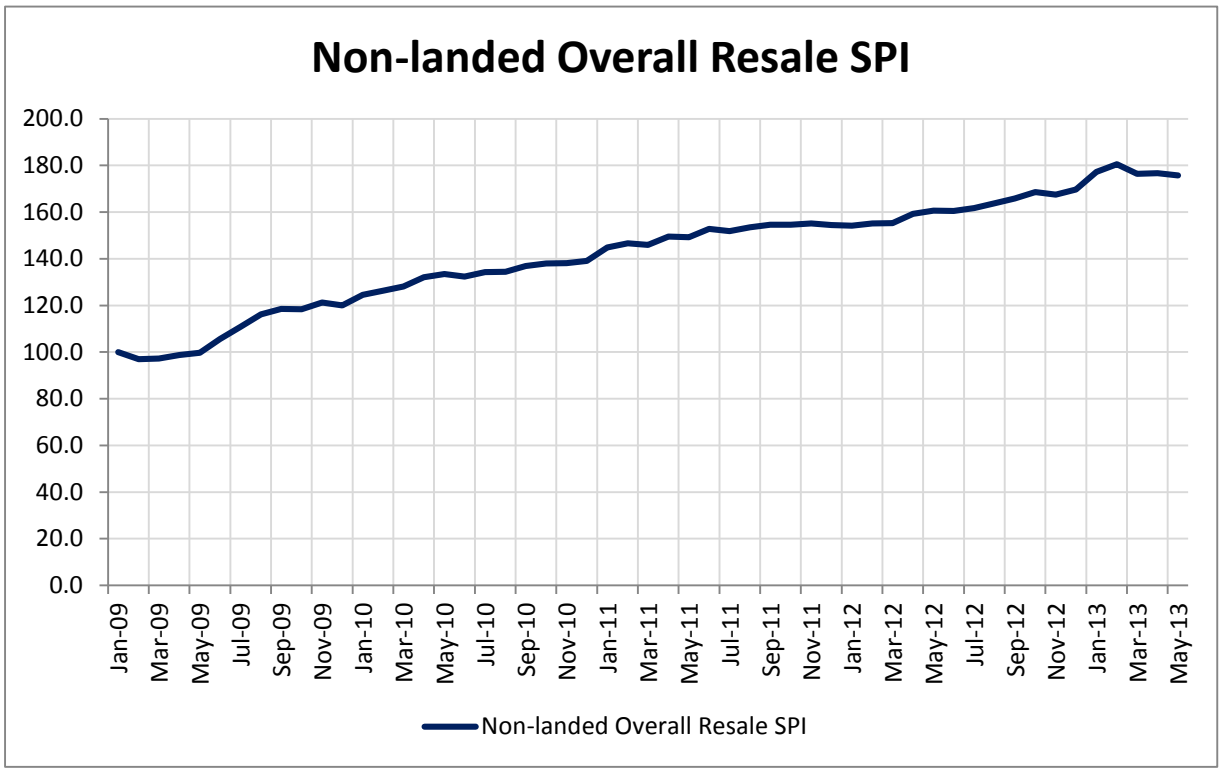
Following the above steps, the non-landed resale price index is computed as follows:

Month	Beta (β)	Non-landed Overall Resale SPI	% change from previous month
Jan-09	.000	100.0	2.09%
Feb-09	-.031	96.9	-3.09%
Mar-09	-.029	97.2	0.28%
Apr-09	-.012	98.8	1.68%
May-09	-.003	99.7	0.89%
Jun-09	.054	105.6	5.92%
Jul-09	.103	110.8	4.98%

Aug-09	.149	116.1	4.75%
Sep-09	.169	118.5	2.03%
Oct-09	.168	118.3	-0.12%
Nov-09	.193	121.3	2.50%
Dec-09	.182	120.0	-1.10%
Jan-10	.220	124.6	3.87%
Feb-10	.234	126.4	1.41%
Mar-10	.248	128.1	1.37%
Apr-10	.278	132.1	3.14%
May-10	.288	133.4	0.98%
Jun-10	.280	132.3	-0.81%
Jul-10	.295	134.3	1.50%
Aug-10	.296	134.4	0.08%
Sep-10	.314	136.9	1.83%
Oct-10	.322	138.0	0.79%
Nov-10	.323	138.2	0.17%
Dec-10	.330	139.1	0.65%
Jan-11	.370	144.8	4.11%
Feb-11	.382	146.6	1.22%
Mar-11	.378	145.9	-0.44%
Apr-11	.402	149.6	2.49%
May-11	.400	149.2	-0.25%
Jun-11	.424	152.8	2.44%
Jul-11	.418	151.8	-0.65%
Aug-11	.428	153.5	1.09%
Sep-11	.436	154.6	0.72%
Oct-11	.436	154.6	-0.01%
Nov-11	.440	155.2	0.39%
Dec-11	.434	154.4	-0.51%
Jan-12	.433	154.2	-0.17%
Feb-12	.439	155.1	0.63%
Mar-12	.440	155.3	0.11%
Apr-12	.465	159.2	2.51%
May-12	.473	160.6	0.85%
Jun-12	.473	160.5	-0.02%
Jul-12	.481	161.7	0.73%
Aug-12	.493	163.8	1.29%
Sep-12	.506	165.8	1.25%
Oct-12	.522	168.5	1.63%
Nov-12	.516	167.5	-0.60%
Dec-12	.529	169.7	1.27%
Jan-13	.572	177.2	4.45%
Feb-13	.591	180.5	1.85%
Mar-13	.568	176.4	-2.24%
Apr-13	.569	176.6	0.10%

May-13	.560	175.7	-0.50%

Figure 2.2.3 Non-landed Overall Resale SPI (January 2009 to May 2012; January 2009=100)



2.3. Model Limitations

A main limitation of hedonic price index is associated with the *index revision* problem. As new transaction data is being captured into the population, population parameters change. And as a result, the hedonic model may also be affected in terms of changes to the coefficient associated with each variable.

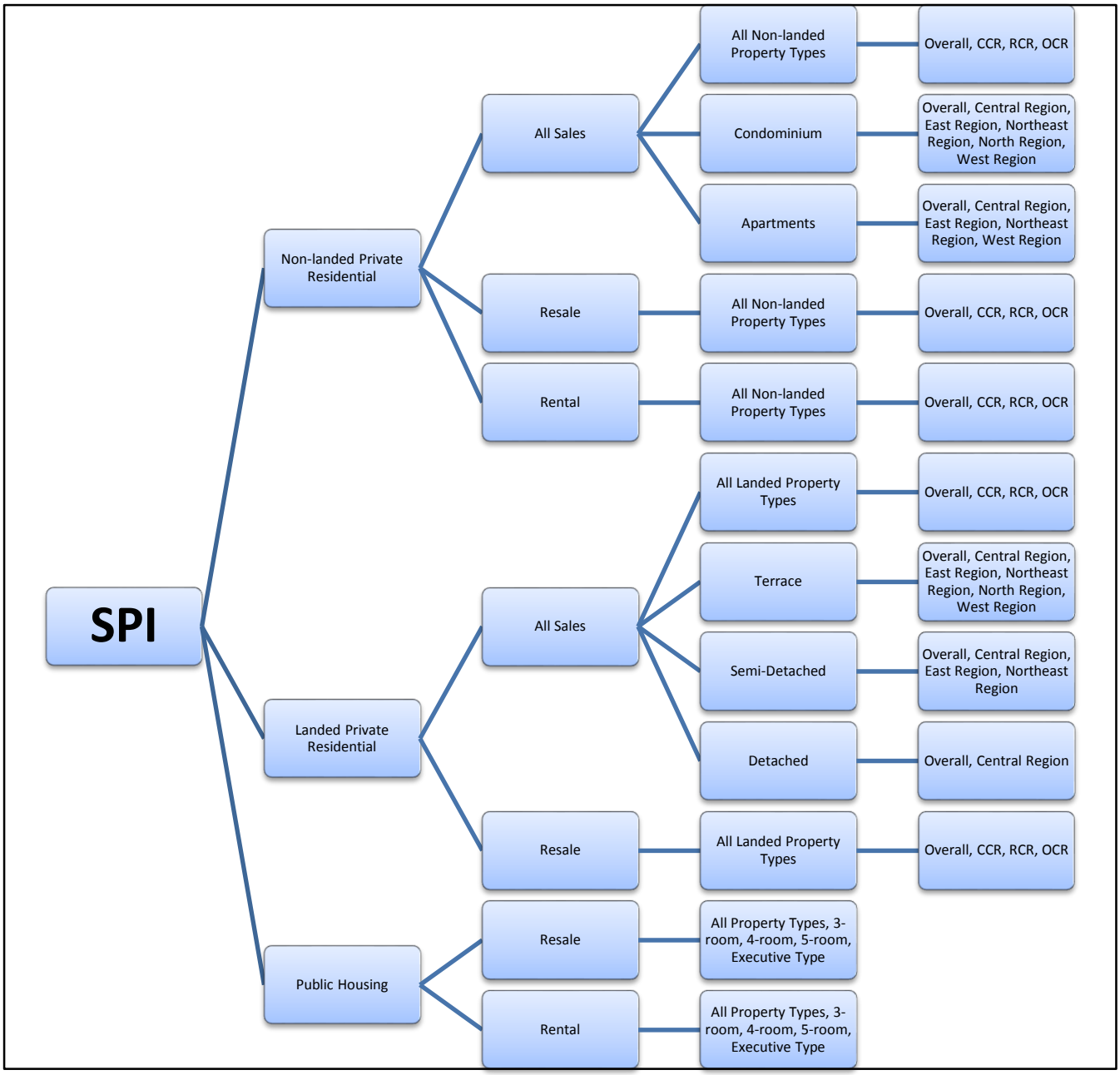
However, as the population grow bigger, the regression model tends to a more stabilized state, as each additional piece of data would cause less volatility in the model. A number of trusted academic researchers suggest that the advantages of the hedonic approach outweigh its disadvantages.

3. SPI basket of sub-indices

The SPI basket of sub-indices cover three major housing sub-markets in Singapore, namely the private non-landed housing market, the private landed housing market and the public (HDB) housing market.

For both non-landed and landed housing markets, SPI provides detailed breakdowns on a regional basis. For each sub-market, three indices – All Sales, Resale and Rental - indices are computed. As such, the SPI basket includes a total of 53 sub-indices. A layered tree map below showcases the SPI basket structure.

Figure 3.0 The SPI Sub-indices Structure



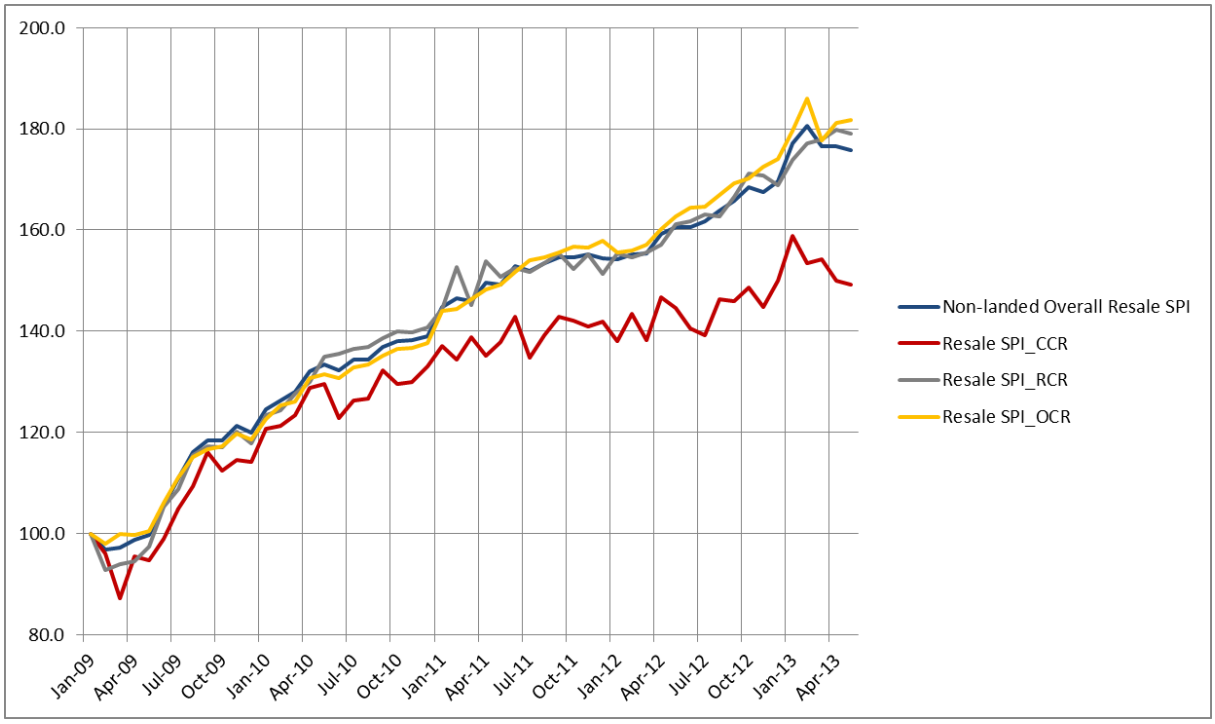
3.1. Example of Regional Sub-indices

Figure 3.1 shows the non-landed private resale SPI as well as regional sub-indices based on the sub-baskets of resale transactions in the Core Central (CCR), Rest of Central (RCR) and Outside Central (OCR) regions, all using January 2009 as the base period.

Indices that are disaggregated by region can be useful for tracking price behaviours in different regional segments of the non-landed residential market. SPI_OCR, the index for the Outside Central Region, shows that properties in the suburbs appreciated at the fastest pace compared with properties in the city centre and city fringe areas between March 2009

(the market trough following the Subprime crisis) and May 2013. The rate of growth in OCR is followed closely by that in the RCR. CCR's price gain is the smallest amongst the 3 regions over the same period.

Figure 3.1 The Non-landed Resale SPI, Core Central Region Resale SPI, Rest of Central Region Resale SPI and Outside Central Region Resale SPI (January 2009 to May 2013; January 2009=100)



3.2. Example of Rental Sub-indices

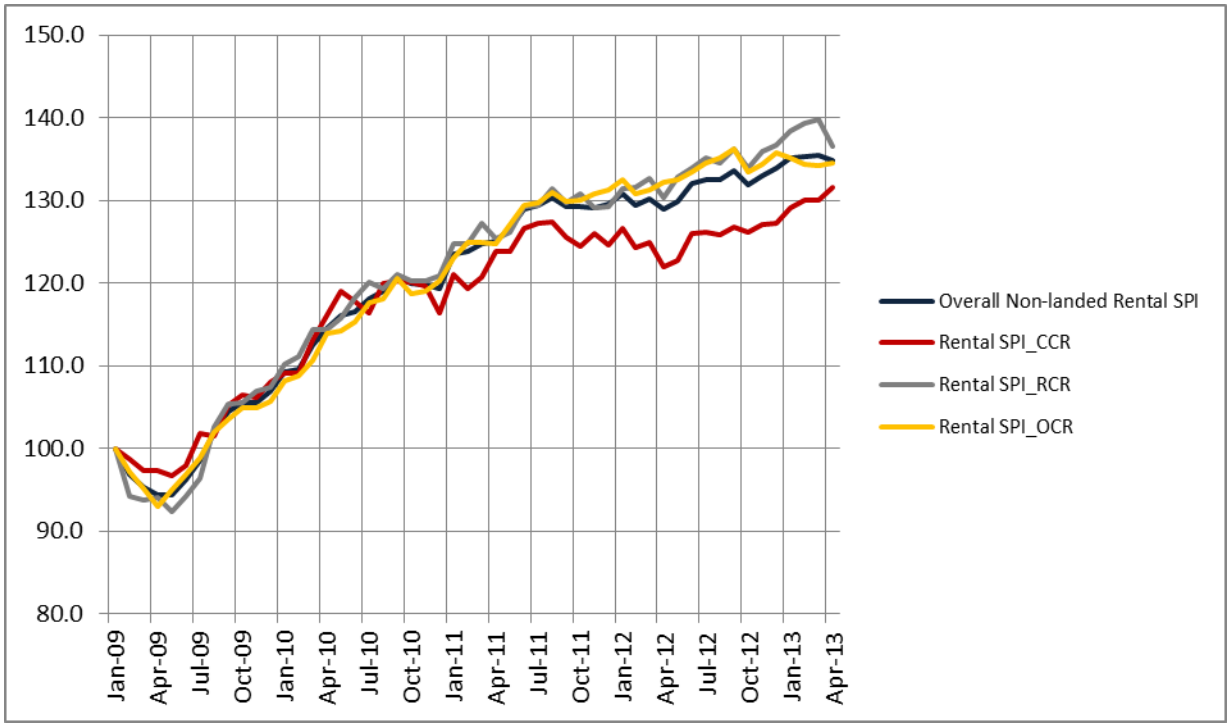
Figure 3.2 shows the non-landed private rental SPI as well as regional sub-indices based on the sub-baskets of rental transactions in the Core Central (CCR), Rest of Central (RCR) and Outside Central (OCR) regions, using January 2009 as the base period.

The rental SPI hedonic model is modified from the resale model, by substituting the unit resale price by unit rental price per month.

It is also worth noticing that the basket of characteristics which affect resale prices may not apply perfectly to the rental price model. For example, the announcements of new MRT stations should not have a direct impact on rents of the properties in the surroundings. In this case, the operation of MRT stations should be the appropriate characteristic to be factored in.

As compared to the resale SPI, rental prices appreciated less than the resale prices across the board between March 2009 and April 2013. This translates to a general downtrend on gross rental yield over this period.

Figure 3.2 The Non-landed Rental SPI, Core Central Region Rental SPI, Rest of Central Region Rental SPI and Outside Central Region Rental SPI(January 2009 to April 2013; January 2009=100)



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