

# A cluster analysis approach to examining Singapore's property market

Chan Lily, Ng Heng Tiong and Rishi Ramchand<sup>1</sup>

## Introduction

The rapid rise of property prices following the Global Financial Crisis has featured prominently on authorities' radar screens across Asia. Price indices reached new nominal highs in several countries, while emerging signs of speculative behaviour led authorities in some countries to intervene to temper exuberance and promote more stable dynamics.

Property is an important sector in Singapore. It is the largest component of household wealth. Mortgage loans form a substantial portion of the banking systems' loan books, while the construction sector is a material contributor to economic growth. Property market stability is therefore closely linked with macroeconomic and financial stability.

Crises in property markets have sown the seeds of steep recessions and financial crises in the past (Reinhart and Rogoff, 2009). The identification of booms and busts in the property market is therefore a strand of research of perennial importance. This paper presents a data-driven approach called clustering analysis to identify different states of the property market.

## Literature review

The literature that analyses the determinants of housing prices and identifies booms and busts in real estate prices can be divided into three broad categories. The first category models the probability of boom and bust episodes occurring. The second category seeks to explain deviations of market prices from model-implied prices. Studies in both these categories begin by identifying thresholds against which housing can be deemed over- or undervalued, often (but not always) using macroeconomic fundamentals. The third category adopts numerical or data-driven techniques to detect booms and busts using a dataset of fundamental indicators.

Within the first category of studies, Agnello and Schuknecht (2009) used a random effects panel probit model to model the probabilities of booms and busts. Following Harding and Pagan (2002) and Jaeger and Schuknecht (2007), they focused on persistent deviations, which were more likely to have distortionary effects on the economy. Bunda and Ca' Zorzi (2009) extended Agnello and Schuknecht (2009) by linking the probability that a peak in house prices triggered a crisis to fundamentals. More recently, Phillips and Yu (2011) concluded that there was residential real estate exuberance in Singapore in 2007 and 2008, as well as from late 2009 to January 2011. They computed a test statistic for explosive behaviour in time series, and compared it against an asymptotic distribution.

In the second category, the IMF (2011) used cross-country regressions to identify global factors that contributed to the near decade-long global housing price boom in the run-up to

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the 2007 financial crisis. More recently, Tsounta (2009) and Gattini and Hiebert (2010) used error-correction models to estimate equilibrium prices in Canada and the euro area respectively, and to explain deviations of actual prices from equilibrium. Both studies used a combination of income, financing and demographic explanatory variables. Klyuev (2008) and Ahuja et al (2010) each used two methods – a panel regression approach and an asset-pricing approach – to assess overvaluation in the United States and in China, respectively. The first approach explained deviations from equilibrium using economic fundamentals, while the second explained them by deriving a relationship between prices and rents.

In the third category, Leung et al (2008) applied a clustering analysis approach to formulate a simple characterisation of the Hong Kong property market from 1996 to 2008 using a variety of demand-side variables. Periods of over- or undervaluation were grouped together based on their similarity.

## Historical evolution of Singapore's property market

Between 1990 and 1996, the Urban Redevelopment Authority (URA)'s<sup>2</sup> Private Residential Property Price Index (PPI) more than doubled. Figure 1 shows price and transaction trends as well as key policy measures introduced since 1990. The upswing reflected long-term fundamental factors, such as high income and savings growth and rapid household formation, as well as short-term catalytic factors, such as low interest rates and foreign buying interest. In addition, rule changes in 1993 to facilitate home ownership allowed Central Provident Fund (CPF)<sup>3</sup> funds to be used to cover mortgage interest payments, and allowed Housing Development Board (HDB)<sup>4</sup> resale flat buyers to take on larger loans.

On 14 May 1996, the government announced a package of prudential and administrative measures aimed at stabilising the market. It restricted property purchases by non-Singaporeans and companies, and released more state land for development. To discourage speculative activity, a stamp duty and a capital gains tax were applied to sales of property within three years of purchase. These measures proved effective: the private property price index eased by about 16% from its peak in Q2 1996.

The onset of the Asian Financial Crisis (AFC) in mid-1997, however, led to much larger declines in both prices and transactions. The PPI reached its trough in Q4 1998, 45% below its 1996 peak. To support the market, the government relaxed stamp duties for both sellers and buyers, while developers were allowed to offer a Deferred Payment Scheme (DPS) under which purchasers could defer payments until the completion of the property.

As Singapore recovered from the AFC, private residential property prices rose 40% between end-1998 and 2000, but declined again after the collapse of the dot-com bubble in 2001, the September 2001 terrorist attack and the 2003 SARS crisis. These events prompted the government to lift the capital gains tax and to allow foreigners access to Singapore dollar property loans. Between 2003 and mid-2005, stamp duties were reduced by 30%.

The loan-to-value (LTV) limit of 80% introduced in 1996 was raised to 90% in July 2005.<sup>5</sup> Of the minimum 10% down payment, the cash component was reduced to 5%. Developers were

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<sup>2</sup> The URA is Singapore's national land-use planning and conservation authority.

<sup>3</sup> The CPF is a statutory board that administers Singapore's national social security savings plan.

<sup>4</sup> The HDB is Singapore's public housing authority.

<sup>5</sup> The LTV limits were raised to give banks more room to manage their risk after the government decided that financial institutions would hold first charge on home loans instead of the CPF, as was the case before.

also given more time to complete projects. These measures aided the recovery in the property market between 2005 and 2006, backed by robust global growth, improved medium-term growth prospects for Singapore and an accompanying rise in capital inflows.

Between end-2006 and their peak in Q2 2008, property prices rose about 36%, led by the high-end segment of the property market and supported more broadly by demand from new immigrants. There was, however, also evidence of short-term speculative demand. Against this backdrop, the stamp duty concession was withdrawn in December 2006 and buyers were required to pay the stamp duty within 14 days of accepting their Option-To-Purchase (OTP).<sup>6</sup> The DPS was withdrawn in October 2007.

The Global Financial Crisis in Q3 2008 had a severe impact on the Singapore property market. The PPI declined by about 25% from its peak, and transaction activity waned. In response, the government suspended the supply of land to developers and allowed them to phase the construction and sale of their projects. Demand recovered strongly after Q2 2009, however, as economic recovery gained traction and interest rates fell. The PPI rose 15.8% in Q3 2009, the largest q-o-q increase since Q1 1981. The government announced measures on 14 September 2009 aimed at pre-empting a speculative bubble. It increased land supply, withdrew loan schemes that could have encouraged speculation, and decided not to renew the aforementioned concessions for developers.

New sales of private residential property moderated following these measures. However, transaction activity rebounded in 2010, prompting further measures in February and August 2010. Once again, moderation was temporary, prompting further tightening of LTV limits and sellers' stamp duty (SSD) terms on 13 January 2011.

## Cluster analysis

Cluster analysis refers to a collection of methods used to segregate a set of observations into groups based on their similarity/dissimilarity. Leung et al (2008) showed how one such method, called the K-means method, could be used to place the Hong Kong property market in one of several such groups, to reflect the stability of the property market at any one point in time. We use the K-means method as well, but extend the analysis to include supply-side variables.

The K-means method groups observations in a dataset into K clusters based on how close an observation is to the mean of the observations in each cluster. There are three steps.<sup>7</sup>

1. Assign observations to K clusters. (We do this randomly, but it is possible to optimise the initial assignment.)
2. Calculate the (squared) distance of each observation from the mean of each cluster. If an observation sits closer to the mean of another cluster than the one it currently resides in, reassign the observation to that cluster, and recalculate the means of both clusters.
3. Repeat the process until none of the observations needs to be reassigned.

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<sup>6</sup> An interested buyer can pay 1% of the price of a property for the exclusive right to decide within 14 days whether or not to buy the property. This is called an Option-to-Purchase (OTP).

<sup>7</sup> In order to ensure that each variable receives equal weight in the procedure, we standardise each series by subtracting its sample mean and dividing by its sample standard deviation.

The final step is to calculate a “**cluster score**” for each cluster by adding up the means of each variable for the cluster.

Cluster analysis provides a quick summary statistic of the state of the market as explained by a combination of indicators. It provides a basis for comparing moderate states of the market, as opposed to states with extremely high or low values. The ability to monitor the moderate states is useful as it facilitates preparation for policy action. One shortcoming of this approach is that results are sensitive to the initial allocations and data updates. We find that, while results do vary slightly as new data points are included, the trend remains broadly the same in our case.

## Data and construction of cluster score

Various forces have shaped the behaviour of the private property market, each exerting its influence more or less strongly at different points in time. These forces are domestic demand, both underlying and speculative demand; external demand; supply-side factors, including construction costs; and financing conditions. While an analysis that attempts to address all of the different factors would likely be intractable, we want our choice of variables to reflect as wide a range of forces as possible. We consider 13 variables, listed in Table 1, some of which have been considered in other studies. Data are quarterly, from Q1 1996 to Q4 2010.

Of the 13 variables, we choose the eight listed in bold font. GDP growth is excluded as the STI does a better job of capturing overall domestic investment sentiment. SIBOR, although an important reference rate for mortgages, has been low for several years and is unlikely to be a significant driver of the recent evolution of the market. M3, meanwhile, does not track PPI well. We exclude pipeline supply because the vacancy rate already reflects supply conditions and does so with less lag. Finally, we omit population growth as the data are annual.

We use nine clusters in our analysis. While a common rule of thumb<sup>8</sup> suggests six clusters may be sufficient, we opt for a larger number to allow us to make finer distinctions between observations (but not so large as to make these distinctions ambiguous). Bayesian-type information criteria also favour a larger number of observations.

## Results and analysis

Figure 2 and Table 2 display the results of the cluster analysis. The coloured bars in Figure 2, read against the left-hand axis, give the cluster scores. A higher cluster score corresponds to a higher degree of upward price pressure or exuberance. For comparison, we have plotted the PPI on the same chart, as one measure of the state of the property market. The cluster scores trace the evolution of the property market reasonably well, including the peaks in 1996 and 2007. The prolonged slump from the late 1990s to the middle of the last decade is also captured.

Identifying the drivers of the property market at different parts of the cycle would enable a better understanding of the dynamics of the market, which would go some way to facilitate appropriate policy thinking and responses. The peaks in 1996 and 2007 (Cluster 9 or red

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<sup>8</sup> Number of clusters = square root of half the number of observations.

bars) reflected strong contributions from indicators of speculative activity. Investment sentiment was also high, as suggested by the contribution of the real stock index. It was common during these periods for investors to engage in “flipping” properties, that is, placing a modest initial deposit to secure ownership of a newly launched property, and then selling it to realise capital gains before more substantial payments came due. Demand from foreigners and companies and low vacancy rates also contributed to price pressures.

Thus, there was a multitude of factors that propelled property prices to historic highs: it is for this reason that property market measures in Singapore tend to involve more than one tool. Also, not all indicators are necessarily at their individual maximum values in the cluster with the highest score (ie Cluster 9), so there is a need to monitor a range of indicators.

The drops in cluster score from the two peaks suggest that the anti-speculative measures introduced in May 1996, and the termination of the DPS, land sales and the deferment of public construction projects after 2006 helped. The cluster score fell between Q2 and Q3 1996. Likewise, it moved from level 9 in Q4 2007 to level 7 in Q1 2008.

The property market stayed between Clusters 1 and 3 in the late 1990s and the mid-2000s. With the market already cooling down in late 1996, the AFC and the ensuing recession took the wind out of the sails of the market very quickly. Weakness persisted through 1998 in spite of the withdrawal of some of the tightening measures taken two years before. Between Q1 1998 and Q4 1999, all eight indicators contributed negatively to the cluster score. This was true as well between Q3 2001 and Q4 2004, after the collapse of the dot-com bubble, the September 2001 attacks and the SARS crisis.

After 2004, however, robust global growth provided the basis for a nascent recovery in the property market. The cluster score rose to level 4. Our analysis suggests that the strongest contributor to the resurgence of the property market in 2006 was demand from foreigners and companies. This was likely, at least in part, due to the series of policy changes in 2005 that removed some of the restrictions on foreign participation in the property market.

Favourable macroeconomic conditions persisted into 2007, but the sudden upturn in the market suggests that other factors were at play as well. Supply was unable to keep up with demand. Perhaps as a result, potential buyers turned to the rental market, driving the yield on investment in property higher. Investors may have been encouraged by healthy rental returns to place their funds in the property market. Indeed, the share of sub-sale transactions rose dramatically in a short time. Positive wealth and income effects from other asset markets may have bolstered ebullience. Rising construction costs were another factor.

The PPI fell for four consecutive quarters from Q3 2008, but recovered sharply. The property market has since continued to face price pressures, with cluster scores between level 6 and level 8. However, the decomposition shows sub-sales contributing less to these pressures, reflecting the effect of the government’s measures. Indeed, other drivers seem to have taken over, notably transaction activity and spillovers from public housing. A strong rebound in equity markets may also have boosted investment sentiment. In addition, a further tightness on the supply side, seen from the vacancy rate, pushed prices upward. While the government has carried out a number of land sales exercises, it will take a while for new properties to be completed.

## Conclusion

Academics and policy institutions have taken several approaches to monitoring and understanding the behaviour of property markets. Clustering analysis is one such approach. It offers a tractable characterisation of the property market, which is particularly informative when the market is in a moderate state. Applied to the last 15 years of data on Singapore’s property market, the methodology identifies periods of ebullience and sluggishness in prices,

and captures the effects of events that had a bearing on the property market over that time. It also shows tentative evidence of the efficacy of recent policy measures to promote stability in the market.

At the same time, we recognise the limitations of this approach, such as its sensitivity to the initial allocation of observations to clusters and the inclusion of new data points, and that it is not designed to evaluate the statistical significance or importance of the variables used.

As a concluding remark, this paper focuses exclusively on the private property market, although approximately 80% of housing in Singapore is public housing. We focus on the private housing market because access to public housing, which is subsidised by the government, is governed by strict rules and restrictions to ensure that it fulfils its aim of providing affordable housing for Singaporeans. A study of the interaction of the private and public property markets is a topic for future research.

Table 1  
**Potential drivers of the property market**

<b>Domestic demand</b>	
Population growth	One way of gauging the rate of household formation, which contributes to housing demand, is to look at population growth.
<b>Real HDB Resale Price Index</b>	HDB “upgraders” could be a significant source of demand in the private market, if the valuation of private properties becomes relatively more attractive.
GDP growth	National economic activity affects household incomes and wealth, and therefore has a bearing on the demand side of the property market.
<b>Real STI</b>	The Straits Times Index (STI) is the benchmark stock index in Singapore. We use it as a proxy for domestic investment sentiment.
<b>Speculative activity</b>	
<b>Sub-sale share of transactions</b>	A sub-sale occurs when the seller of a property has not yet received the title to the property. <sup>1</sup> Sub-sales are commonly seen as a proxy of speculative buying and selling of properties in Singapore.
<b>Transactions/ Stock</b>	Transactions, expressed as a percentage of the housing stock to account for growth over time, are an indicator of exuberance in the market.
<b>External demand</b>	
<b>Foreigner and company share of transactions</b>	Purchases by foreigners and corporate buyers are more likely to be correlated with the business cycle than purchases by Singaporeans.
<b>Other investment inflows into the banking sector</b>	Some of the funds foreign investors use to buy property in Singapore appear in this component of the balance of payments statistics. The series is smoothed by taking a two-quarter moving average.
<b>Supply</b>	
100,000/Unsold units in the pipeline	The number of unsold property units in the pipeline is a direct measure of property availability and supply in the market. We divide 100,000 by this figure to yield a number of a convenient order of magnitude.
<b>100/Vacancy rate</b>	The vacancy rate reflects the percentage of the existing stock of properties that is currently unoccupied. We invert it to reflect that we expect the vacancy rate to be low when the property market is in a state of exuberance, and vice versa.
<b>Construction costs</b>	
<b>Real Tender Price Index</b>	The Tender Price Index, compiled by the Building and Construction Authority (BCA), is an index of construction costs that incorporates the cost of materials, manpower, plants and machinery, as well as overheads and profits
<b>Financing and liquidity conditions</b>	
M3 growth	Although not a perfect gauge, we explore domestic broad money growth as a measure of liquidity conditions.
Interest rates	The benchmark interest rate in Singapore is the Singapore Interbank Offered Rate, or SIBOR. It is also the reference rate for most mortgages; mortgage borrowers pay a spread over SIBOR. As Singapore uses the exchange rate rather than interest rates as a monetary policy tool, external factors exert a strong influence on interest rates.

<sup>1</sup> A sub-sale refers to “the sale of a unit by one who has signed an agreement to purchase the unit from a developer or a subsequent purchaser before the issuance of the Certificate of Statutory Completion and the Subsidiary Strata Certificates of Title or the Certificates of Title for all the units in the development”. (URA)

Table 2

**Contributions of indicators to cluster scores**

	<b>HDB RPI/GDP Deflator</b>	<b>STI/ GDP Deflator</b>	<b>Sub-sale Share</b>	<b>Trans- actions/ Stock</b>	<b>Foreign + Co. Share</b>	<b>Oth. Inv. Inflows (2qma)</b>	<b>100/ Vacancy Rate</b>	<b>TPI/ GDP Deflator</b>	<b>Cluster Score</b>
Cluster 1	-0.53	-1.12	-0.58	-0.74	-0.48	-1.21	-0.81	-0.28	<b>-5.74</b>
Cluster 2	-0.64	-0.20	-0.57	-0.17	-0.49	-0.28	-0.57	-0.85	<b>-3.78</b>
Cluster 3	-0.12	-0.33	0.11	-0.72	-0.62	0.99	-0.79	-0.92	<b>-2.41</b>
Cluster 4	-0.81	0.63	-0.75	0.12	1.84	0.95	0.00	-0.18	<b>1.80</b>
Cluster 5	1.15	-0.38	0.70	-0.36	-0.16	0.38	0.08	0.60	<b>2.01</b>
Cluster 6	1.85	0.93	0.51	1.31	-0.26	-0.53	1.33	0.43	<b>5.58</b>
Cluster 7	0.65	0.49	1.09	-0.73	0.10	1.14	0.74	2.58	<b>6.07</b>
Cluster 8	2.30	1.31	-0.26	0.93	-0.10	0.92	2.26	0.20	<b>7.56</b>
Cluster 9	-0.36	1.32	1.46	1.75	1.49	0.72	1.22	0.85	<b>8.44</b>

**Figure 1: Private residential property price and transaction trends and key policy measures introduced since 1990**

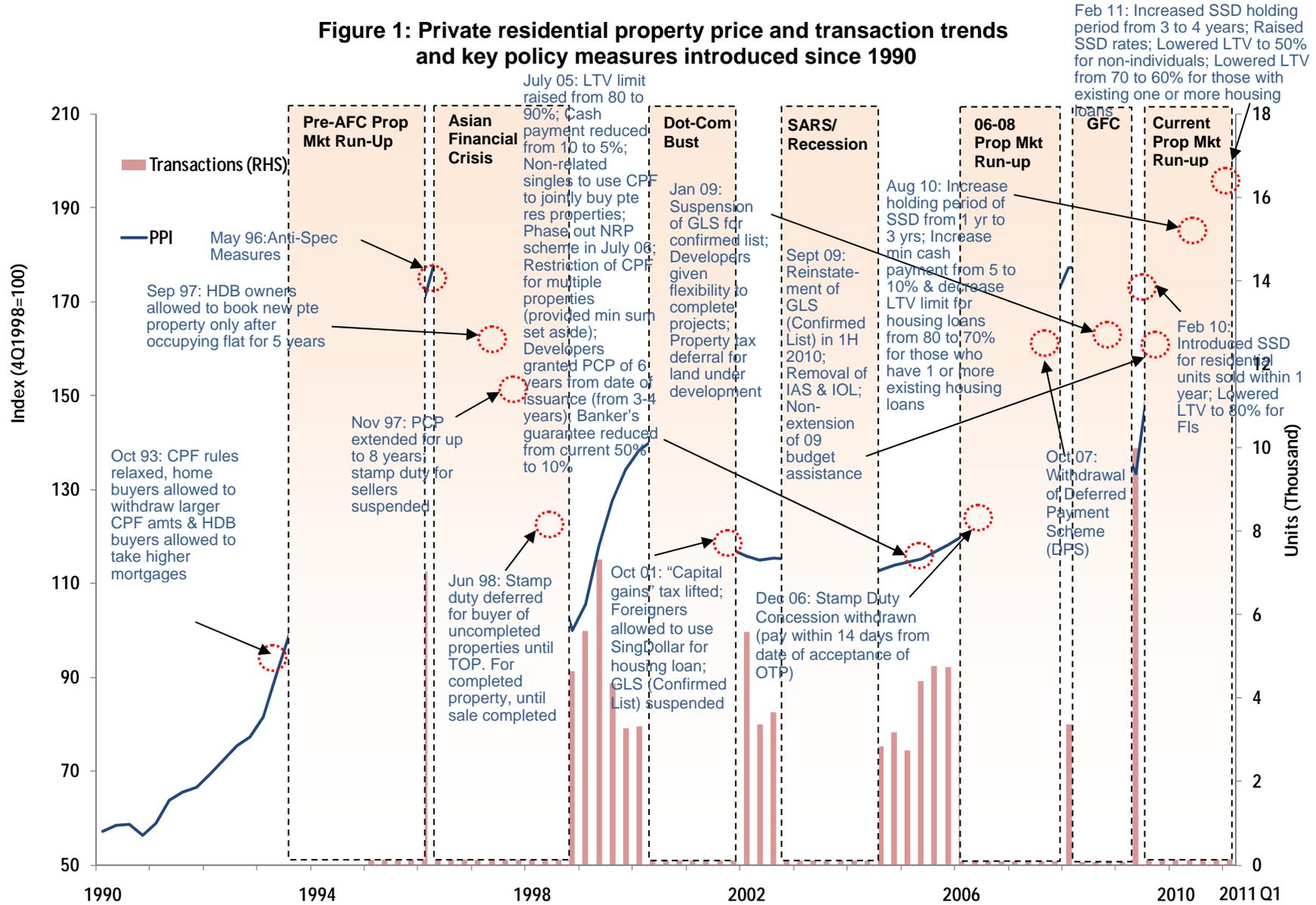
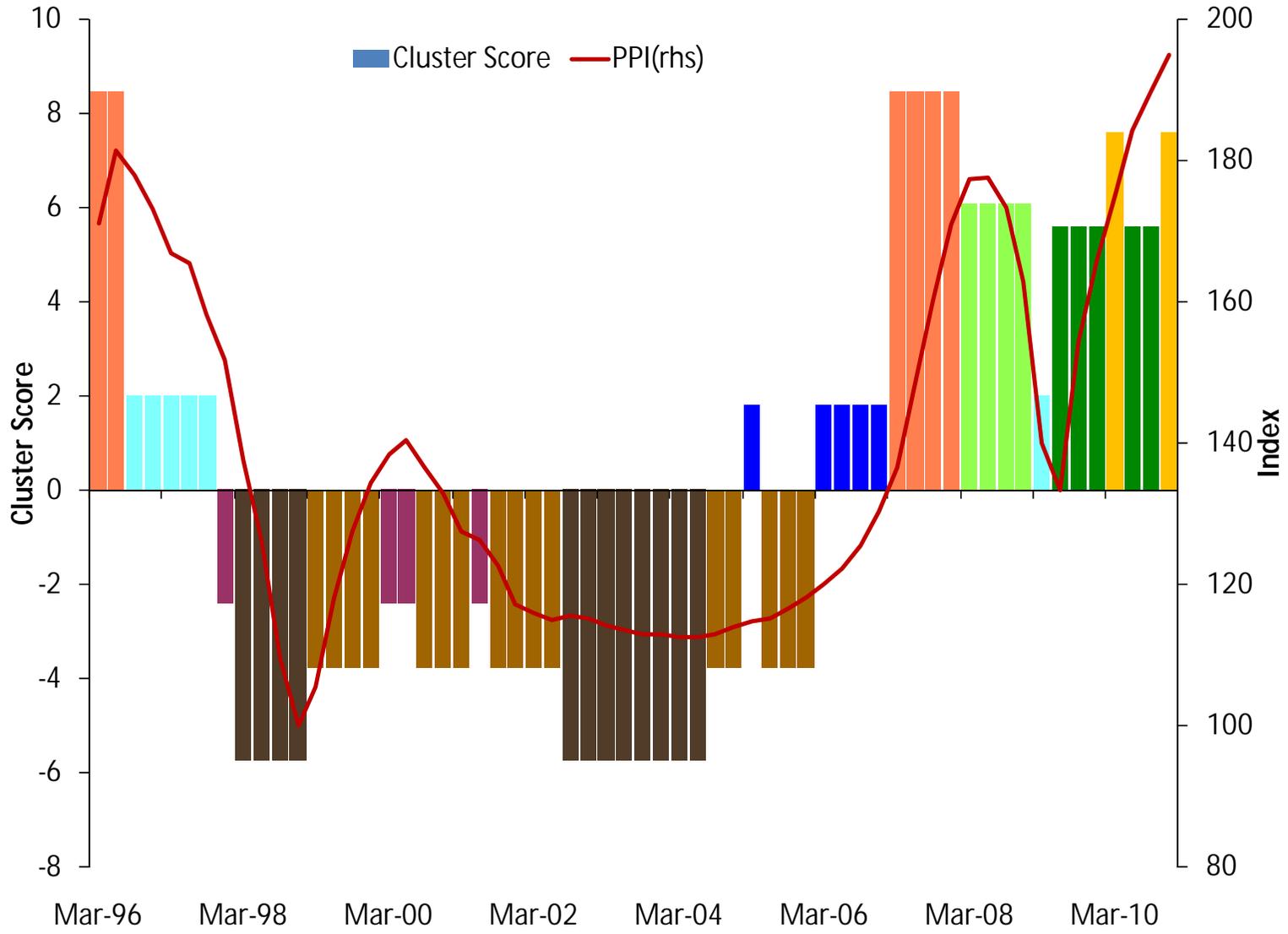


Figure 2: Cluster scores and PPI



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