Maybe, Singaporean housing is not that bubbly

Philip Inyeob Ji[1]

Department of Economics, Dongguk University Seoul

Abstract

We utilize a novel method from Phillips, Shi and Yu (2015) to investigate whether Singaporean real estate markets have experienced explosive expansions. This method involves a doubly recursive right tailed unit root test which can be used for real time policy decisions. We find that the Singaporean real estate markets were subjected to explosive growth (where rents grew at a higher rate than property prices) during the Global Financial Crisis. We also find that two specific segments lead the Singaporean residential housing markets and commercial markets. Additionally, it is found that these two leading sectors affected the growth of other markets positively in normal periods and negatively during the Global Financial Crisis.

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[1] Email: philipji0422@gmail.com

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1 Introduction

On the 31st of July 2019, the United States Federal Reserve Board voted to reduce its benchmark interest rate by 0.25 percent in an attempt to protect the record long expansion of the United States economy. This interest rate cut, together with concerns about a global slowdown and trade tensions between the United States of America and China, is likely to present challenges for countries that have experienced rapid real estate price growths recently. An example would be Singapore. According to Baltagi and Li (2015), home purchase prices in Singapore have almost tripled between 2005 and 2008 alone for which the Singaporean government has taken measures.[2] Moreover, the interest rate in Singapore is closely linked to global financial markets, because, unlike most other countries, monetary policy of Singapore is centred on the exchange rate, not the interest rate. Therefore, given the rate cut, real estate markets may re-emerge as a policy concern in Singapore.

Singapore's property market is unique as it is a city state, 718.3 km^2 in size. The availability of land for development is limited and managed by the government via a government land sales program. From 2005 to 2012, the population of Singapore grew 23% from 4.3 million to 5.3 million. At the same time, the non-resident population (studying, working or visiting) in Singapore increased 88% from 0.8 million to 1.5 million (see Figure 1). Much of the non-resident population live in rental properties as government developed

[2] See Figure 1 in Baltagi and Li (2015).

properties[3] are not available to non-residents. In the same time period (2005-2012), the number of private residential properties increased by approximately 48,000 units. This created both a property and rental crunch which saw an increase in both prices. Immigration policy was tightened around 2012 and population growth slowed down, which suppressed rents.

The Singapore government attempts to "manage the property cycle to prevent booms and busts", according to a former Singapore finance minister, Tharman Shanmugaratnam (The Business Times Singapore, 11 November 2009). Property easing measures implemented in 2005 witnessed a boom in the Singapore property market leading to a peak in 2007.[4] The global financial crisis caused prices to decline in 2008. However, this was short lived as the property market picked up again and housing prices soared in 2009. Although the rapid escalation discontinued, housing prices have been still growing steadily. In response, worries of a property bubble prompted the government to act with a series of anti-speculative measures in an attempt to cool the market; including curbs on foreign speculation and tightening of loan conditions. These cooling measures were rolled out sequentially from 2009 to 2013, tightening controls on mortgages.

Given this background, we contend that it is a meaningful exercise to investigate the

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[3] More than 80% of the resident population live in government developed properties in Singapore.

[4] This includes the relaxation of foreign ownership rules on apartments; an increase of the maximum loan-to-value ratio from 80% to 90%; a reduction of cash down payments from 10% to 5% for home purchase.

dynamics of the Singapore real estate market. Singapore, a city state with limited land and natural resources, relies heavily on economic growth from financial services sector rather than manufacturing. Real estate sector is also a significant part of the economy; hence, housing price is an important policy agenda for Singapore. Its real estate sector, in particular housing, presents a thought provoking case for economic research because 90% of the land is owned and managed by the government. Its policy effect mechanism is likely to be much more transparent and direct than that of other countries'.

While it is a profound concern for policy makers to determine whether speculative bubbles are building up in asset markets, the economic intuition on speculative bubbles is rather simple. If economic fundamentals are the only source of variations in asset prices, it is unlikely that a speculative bubble is present in the market and thus will lead to a financial crisis which is often manifested by an eventual crash in asset prices.

However, it is a demanding task to test for a speculative bubble against fundamentals induced abrupt rises in asset prices because the test requires *not only* an econometric model for excessive movements in asset prices (deflated by their fundamentals) *but also* a correctly specified model for the fundamentals. A recent bubble study (Gioglio et al, 2016) on the UK and Singaporean housing markets proposed model free tests. These authors pay attention to the unique fact that property ownership in Singapore is either freehold or long leasehold of the length in several hundred years. They rely on the intuition that price difference between these two ownership titles would indicate the presence of bubble, while they find no evidence of infinitely lived bubbles.

A notable methodological contribution to the asset bubble literature is Phillips et al (2015) (PSY henceforth). PSY has recently proposed a test for an explosive root in time series data as an effort to combat this difficulty and has spurred a number of empirical applications in the bubble literature. Some of these applications include the US stock market bubbles and crashes in PSY's own work, explosive behaviors in Sterling/US dollar real exchange rate in Bettendorf and Chen (2013) and the Hong Kong housing market bubbles in Yiu et al (2013). Findings from Yiu et al (2013) indicate that Hong Kong has experienced multiple housing bubbles. Huang and Shen (2017) revisit the case of the Hong Kong housing markets and find evidence of multiple bubbles by using the PSY method. Also, Liu et al (2016) apply the PSY method to 70 major cities in China. These authors document that Chinese housing markets have experienced bubbles.

To the best of our knowledge, despite the novelty of the PSY procedure, no attempt has been made to examine in the framework of the PSY method whether Singapore has experienced explosive housing prices. A recent study of the Singaporean housing market is Baltagi and Li (2015). They find for Singapore that national-level home purchase prices and rents are not cointegrated but area-specific prices and rents are cointegrated for the period of 2001 to 2014. Based on these findings, Baltagi and Li (2015) argue that cointegration between housing prices and rents may be uncovered by more refined geographical data. The evidence of cointegration can be interpreted against explosive prices deviations from rents. However, Baltagi and Li (2015) qualify their results by suggesting that markets can still be inefficient in the short run. Further, the findings for Hong Kong, another small autonomous territory, from Yiu et al (2013) are available for a comparative analysis which may offer implications useful for Singaporean policy makers.

While Yiu et al (2013) find multiple episodes of bubbles in price to rent ratios for Hong Kong, some of them are negative bubbles. These crashes in prices relative to rents are time stamped to be 2000 and 2008. Although Yiu et al (2013) do not discuss possible causes of these two episodes, it is most obvious that they correspond to the dot-com crash and the Global Financial Crisis during which global asset markets contracted rapidly. The PSY procedure allows us to examine whether Singaporean housing market has been affected similarly to that of Hong Kong.

In addition, we seek to understand whether prices or rents drove the price to rent ratios in the 2000s. Historical episodes relevant to Singapore are the Global Financial Crisis and migration. Asset prices including housing price collapsed during the crisis period of 2007 to 2008. Between 2003 and 2008 Singapore received an influx of the non-resident population (see Figure 1), which is likely to have pressed up rental prices. A simple time series model can provide information of price rent dynamics in the price to rent ratios.

Our results are as follows. We find that several Singaporean housing sectors have experienced a negative bubble. Also, rents grew at a faster rate than property prices at times. Further, explosions were found in rental rather than property prices in the period up to the Global Financial Crisis. It appears that the rapid increase in the non-resident population may have been a contributing factor to the housing price dynamics in Singapore.

This paper is organized as follows. Section 2 explains methodologies. Data and the empirical findings are presented in Section 3. In Section 4, we conclude the paper with some analysis and policy discussions.

2 Methodologies

The PSY procedure is motivated by the allowance for a rational bubble term in the present value models of asset prices. The bubble term may be allowed to grow explosively and implode with a certain probability. Hence, the PSY test finds an explosive root of an univariate time series in double recursion of the standard ADF test framework. The (right tail) distribution of the test statistic is simulated to generate critical values.

PSY proposes a recursive and rolling ADF unit root test in the following form:

$$\Delta y_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} y_{t-1} + \sum_{i=1}^{k} \rho_{r_1,2}^{i} \Delta y_{t-1} + \varepsilon_t \tag{1}$$

where y_t is the random walk with an asymptotically negligible drift, r_1 and r_2 denote the starting point and end point of each recursion and ε_t is an normally distributed error with the mean of zero and variance of $\sigma^2_{r_1,r_2}$.

The null and alternative hypotheses take the forms of

$$H_0: \ \beta = 1$$

$$H_1: \ \beta > 1$$

Equation (1) is estimated by the OLS from the first observation in the minimum window which then expands forward to the last observation recursively. However, once all the recursions have completed, the minimum windows takes the second observation as its starting point of the recursion (i.e. double recursion). This flexible double recursion is to test for the presence of multiple bubbles in the data which distinguishes the PSY procedure from its forerunner developed by the PWY procedure from Phillips et al (2011). The PSY test statistic is defined by

$$\text{GSADF}(r_0) = Sup_{r_2 \in [r_0,1]} Sup_{r_1 \in [0, r_2 - r_0]} ADF_{r_1}^{r_2} \tag{2}$$

where is r_1 the start point of each recursion which is allowed to vary within the range of $[0, r_2 - r_0]$ and $r_2$is the end point of the recursion.

If *GSADF* statistic rejects H_0, a date stamping procedure follows to identify the surge and collapse of bubbles. To this end, we adopt the following backward Sup ADF statistic recommended by PSY.

$$BSADF_{r_2}(r_0) = \ Sup_{r_2 \in [0, r_0 - 1]} ADF_{r_1}^{r_2} \tag{3}$$

The bubble origination estimate denoted by $\hat{r}_e$ and collapse estimate denoted by $\hat{r}_f$ are finally obtained by using the *BSADF*.

$$\hat{r}_e = Inf_{r_2 \in [r_0, 1]} \left\{ BSADF_{r_2}(r_0) > \ cv_{r_2}^{\beta_{Tr_2}} \right\} \tag{4}$$

$$\hat{r}_f = Inf_{r_2 \in [\hat{r}_e, 1]} \left\{ BSADF_{r_2}(r_0) > \ cv_{r_2}^{\beta_{Tr_2}} \right\} \tag{5}$$

where $cv_{r_2}^{\beta_{Tr_2}}$ is the $100(1 - \beta_T)\%$ critical value of the Sup ADF statistic based on Tr_2 observations.

PSY demonstrates that $\hat{r}_e$ and $\hat{r}_f$ provide consistent estimates of turning points of multiple bubble surges and crashes, which is an methodological advancement from the PWY procedure.

An interesting feature of the PSY procedure is the possibility of “negative bubbles”. A traditional view to asset bubbles in the literature is that bubbles cannot be negative due to free disposal of stocks (Tirole, 1985; Diba and Grossman, 1988). For example, Evans (1991) suggests a bubble process

$$B_{t+1} = \left\{ \begin{array}{c} (1+R_{t+1})B_t u_{t+1}, \quad B_t \leq c \\ \left[\xi + \ \pi^{-1}\left(1 + R\theta_{t+1}\left(B_t - \frac{\xi}{1+R}\right)\right)\right] u_{t+1}, B_t > c \end{array} \right\} \tag{6}$$

where B_t is the bubble, R_t is the discount rate, c is a finite constant, $E_t u_{t+1}$ is an exogenous i.i.d. positive random variable, ξ is the seed value to which the bubble reverts upon collapse, $\theta_{t+1}$is a Bernoulli random variable which takes values of 1 and 0 with probabilities π and $1-\pi$ respectively.

However, it is plausible to observe empirically negative bubbles in which case rents grow faster than housing prices. Yiu et al (2013), in fact, use the PSY procedure and offer evidence of negative bubbles for the Hong Kong residential property market. This result is due to the flexibility of the PSY procedure arising from the fact that the GSADF test does not restrict data from drifting downwards explosively. We also observe such explosive increase in rents where housing prices are unable to catch up in the Singapore real estate market. We provide some explanation of this in a subsequent section.

3 Data and Empirical Findings

3.1 Data

We collect from the Urban Redevelopment Authority of Singapore's database quarterly median rentals and median prices of both residential and commercial properties for the period of 1998Q4 to 2014Q3.[5] Rents and prices are reported for each real estate sector under residential and commercial markets; namely, detached house (DET), semi-detached house (SEMI), terrace (TER) and non-landed apartments and condominiums (NL) for residential markets; Office in central areas (OC), Office in fringe areas (OF), Shop in central areas (SC), Shop in fringe areas (SF), Factories (FAC) and Warehouses (WH) for commercial markets.

Median prices and rents are logged and deflated by the Consumer Price Index into real terms. Figure 2 presents the plots of price (P), rent (R) and price to rent ratio (PR) for non-landed sector for an expositional purpose.[6] Price soars in the early 2000s and rises sharply in 2006 immediately before the outbreak of the global financial crisis (GFC). Rent also undergoes an abrupt surge in 2006. Shortly after, they both decline, as the GFC intensifies in the years leading up to 2009. The drastic fall and recovery of the PR ratio plot (placed in the lowest panel) in the GFC years suggests that non-landed housing price, when its fundamental is accounted for, crashed during the GFC, which alludes to the possibility of

[5] The choice of sample period is due to data availability.

[6] The PR ratios are calculated as the prices divided by the annual rent.

a negative bubble.[7]

3.2 The PSY Procedure

Table 1 reports the ADF test results for the PR ratios which indicate that the null hypothesis of unit root cannot be rejected at the conventional significance levels for all the markets except non-landed properties. Given that unit root tests only differentiate the null of I(1) from the alternative of I(0) process, it is not entirely disconcerting that the ADF test finds the ratios I(1).

We proceed to the GSADF test. Table 2 presents the results for price, rent and PR ratios (in the left panel) and the bubble origination and collapse date estimates for PR ratios (in the right panel) at the 5% significance level. The GSADF statistics for the PR ratios indicate that explosions occurred in most markets in the sample period. Moreover, we observe that explosions occurred in both the PR ratios and in price (or rent) of several markets; namely, SEMI, TER, NL, OF and FAC. This suggests that we may be able to infer indirectly the source of explosion between price and rent because time series properties of the PR ratio (the ratio of price to rent) are not independent of price and rent.[8]

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[7] Although we do not present the plots for the other sectors in this section to conserve space, the plunge in the PR ratios is observed widely across Singaporean housing markets.

[8] Bettendorf and Chen (2013) examined both nominal exchange rate for Sterling/US dollar and traded goods price differentials between the UK and USA in the PSY framework. They argue that the price differentials may be the fundamentals of the nominal exchange rates on the basis that bubbles are found in

The explosion origination and crash estimates are tabulated in the right panel of Table 2. Explosions appear around the Global Financial Crisis (GFC) period (circa 2006 and 2009) for most markets, while they emerge in later periods (circa 2012 and 2013) for factories (FAC) and warehouses (WH). Terraces (TER) and central office (OC) market explosion last as long as 6 quarters. The warehouse (WH) market had relatively short lived multiple explosions.

In addition, we find from the BSADF statistics evidence of negative bubbles which is similar to some of the findings from Yiu et al (2013) for Hong Kong residential property market. Figures 3a-3j present the PR ratios, price and rent with their BSADF statistics and the 95% critical values. The surge point of explosions (collapses) in price and rent coincide with a sharp fall (recoveries) in the PR ratios except for factories and warehouses. It follows that rent grew faster or declined more slowly than price during the estimated negative bubble episodes.

We may also be able to make a further inference about sources of explosions from the

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both nominal exchange rate and price differentials while they are not present in real exchange rate once price differentials have been accounted for; that is, bubbles in the nominal rate are counterbalanced by bubbles in the price differentials.

In preliminary analysis, we conducted the bubble accounting from Bettendorf and Chen (2013) by applying the PSY procedure to the price (or rent) deflated PR ratios; however, we were unable to identify price and rent as a direct source of explosion in the PR ratios. Nevertheless, the GSADF statistics raise suspicion that explosions in the Singaporean property markets may be driven by rent. Most residential markets (SEMI, TER, NL) have had explosions in the PR ratios. It appears that rent may contribute to explosions in the PR ratios for semi-detached houses (SEMI) and terrace markets (TER) while price may drive explosions in the PR ratios for non-landed properties (NL). For offices in central (OC) and factories in commercial markets (FAC), rent may be the driver of explosions.

BSADF statistics. The BSADF statistics for price and rent in Figures 3a-3j suggest that explosions occurred in both price and rent in many of these property markets at various points of time. In particular, Figures 3b, 3c and 3f indicate that semi-detached houses (SEMI), terraces (TER) and fringe area offices (OF) experienced more pronounced explosions in rent than price during explosion episodes in the PR ratios, from which we construe that the source of explosions in these markets is likely to be rent rather than price.[9]

High rents could be supporting property prices in the Singapore property market. As rental contracts are usually signed for a period of at least one year, significant lags exist between property price and rentals. As indicated by Figures 3a-3j, the rapid expansion of prices and rents built up in the period leading up to the 2008 financial crisis. Post crisis, prices were increasing at a steady rate, which then eased off around early 2011. It appears that cooling measures combined with a tightened immigration policy took effects on rents and in turn property prices. Even though these results suggest that an explosive behaviour in prices did not develop post 2008, the cooling measures taken by the government could have contributed to the prevention of its formation.

Overall, our findings from the PSY procedure suggest that high rents may be the cause of

[9] Given that the PR ratios are predominantly I(1), one may consider estimating cointegration and error correction models to test whether price and rent are cointegrated in normal periods and whether cointegration breaks during bubble periods. We argue that cointegration tests would provide little practical gain under these circumstances because most of the estimated bubble periods in the present analysis are short lived and offer too few observations.

explosive behaviour in the Singaporean property market. Rather than just concentrating on cooling measures directed at developers and buyers, the policy focus should be placed on ensuring that the growth of available rental units matches immigration (or population growth) forecasts. Preventing excessively high rental seems to be important in easing over speculation.

3.3 Sectorial Dynamics

We found from the BSADF statistics that the occurrence of explosive movements during the GFC period was almost a stylized fact for the Singaporean property markets. However, dates of explosion origination and implosion and its duration were not concurrent across the markets. For example, referring back to Table 2, a bubble started to run up in terrace market in September 2006 and last 12 quarters (3 years), while non-landed properties underwent a two quarter long (6 months) bubble period much later in March 2009.

We now investigate whether any of these markets lead others in bubble formation and whether the leading effect, if any, is symmetric between bubble periods and normal market states. To this end, we estimate vector autoregressive (VAR) models for residential markets and commercial markets separately. It is arguable whether VAR modeling is applicable to the present case because the PR ratios would have a mixture of orders of integration. They would be, as the ADF tests suggest, I(1) in some periods and contain explosive roots in other periods. However, we contend that it is still an informative exercise to investigate the linkages between these ratios by the impulse response because the explosive roots are contained in limited parts of the sample periods and do not dominate the entire periods.[10] The following standard K-dimensional VAR is estimated to obtain impulse response estimates.

$$Y_t = \upsilon + B_1 Y_{t-1} + \cdots + b_p Y_{t-p} + u_t \tag{7}$$

where Y_t is a K $\times 1$ random variable, υ is a K $\times 1$ intercept vector, and the B_1 is K $\times$ K coefficient matrices. u_t is the K $\times 1$ vector of innovations, with $\mathrm{E}(u_t) = 0$ and $\mathrm{E}(u_t u_t^{'}) = \sum_u = PP'$.

Impulse response analysis is used to examine what impact a one standard deviation shock to a variable has on other variables in the VAR system (Lutkepohl, 1991). The null hypothesis of zero impulse responses between variables is interpreted to mean a lack of causality between them. Impulse response estimates are generated from the coefficients of the vector moving average (MA) representation of the VAR model and the residual

[10] Investigation of this technicality is not the main interest of the present article. However, one may refer to Phillips and Magdalinos (2013) in pursuit of this issue.

covariance matrix. That is, the least square estimation is run to obtain estimators for B_i , Σ_u and the residual vector, denoted by $\widehat{B} = \left(\hat{\upsilon}, \widehat{B}_1, \cdots, \widehat{B}_p\right)$, $\widehat{\Sigma_u}$ and $\widehat{u_t}$, respectively. The orthogonalized impulse responses are defined as $\ominus_i = \Phi_i P$ here Φ_i s are the least square estimates of the MA(∞) representation of the VAR. Let $\theta_{kl,i}$ denote an element of $\ominus_i$. $\theta_{kl,i}$ is the impulse response of variable k to a one time impulse in variable l i periods ago. Typically, $\theta_{kl,i}$ is plotted against i with confidence intervals as the impulse response function of variable k to an one time one standard deviation shock to variable l. Finally, the impulse response estimates $\theta_{kl,i}$ are obtained from $\widehat{B}$ and $\widehat{\Sigma_u}$.

We choose the ordering of variables based on Wold causality (Lutkepohl, H., 2005) and the date stamping estimates. The semi-detached house market is placed first followed by non-landed, terrace and detached for residential markets.[11] Figure 4a reports the impulse response estimates with the corresponding 95% confidence intervals. We find that all markets respond to a shock to the semi-detached market statistically significantly for an extended period of time. For example, terrace PR ratio responds to a semi-detached market shock and reverts in approximately 8 quarters (2 years). Moderate responses to non-landed are also observed. In contrast most of the responses to terrace and detached are statistically insignificant.

In turn, we performed the impulse response estimation for the commercial markets in the

[11] We also considered all other alternative orderings but found qualitatively similar results.

ordering of central offices, fringe offices, central shops, fringe shops, factories and warehouses. The estimates are reported in Figure 4b. Fringe offices, factories and warehouses show significant responses to central offices. Especially, fringe offices display almost permanent responses. Warehouses also respond to factories significantly over approximately 8 quarters (2 years).

Overall, the impulse response estimates suggest strong one way causality running from semi-detached house market (and some causality from non-landed) in residential sectors and a substantial degree of causality from central offices in commercial markets.

Having found that semi-detached house, non-landed and central office sectors exert leading forces, we run the following regression for first differenced PR ratios to investigate the effects of these leading sectors on the other sectors during explosive periods:

$$\Delta PR_t = \alpha_0 + \alpha_1 \Delta PR_{t-1} + \alpha_2 \Delta PR_{leader,t-1} + \alpha_3 D + \alpha_4 D \Delta PR_{leader,t-1} + e_t \qquad (8)$$

where ΔPR denotes first differenced logged PR ratio, D denotes an indicator variable (1 for the explosive periods of September 2006 to March 2009; 0 otherwise) and e_t is an iid error. Semi-detached and non-landed are selected as *leader* alternately. For commercial sectors, we use central office as *leader*.

Table 3 reports the estimates for residential markets. The estimates in the third row show the effects of the semi-detached sector. Moderate levels of statistical significance (p-values of 0.11 and 0.08) and positive signs of the estimates indicate explanatory power of semi-detached sector leading detached and non-landed. The magnitude of the estimates is considerable; that is, one unit increase in the semi-detached market is followed by 31% and 36% increases in detached and non-landed sectors in the following quarter in terms of the PR ratio. Non-landed also shows some statistical significance (P value of 0.11) in explaining detached sector. These results suggest that spill over effects originate from the semi-detached house sector in residential markets under normal market conditions, which is a consistent finding with the impulse response estimates.

However, explosive period estimates are somewhat counter intuitive. The dummy interaction terms (D*ΔSEMI and D*ΔNL) reported in the sixth and seventh rows have negative signs in most cases and magnitudes of -18% and -20%, despite their statistical insignificance. We interpret these results in terms of economic significance to suggest that the spill over effects may work reversely in explosive periods.

Additionally, the coefficients on ΔSEMI and D*ΔSEMI (31% and -18% respectively) are markedly different from each other in size. It appears that semi-detached sector exercises a stronger influence on detached sector in normal market state. The same is observed for non-landed and detached.

The results for commercial sector follow in Table 4. In light of statistical significance, central area offices drive up fringe area offices in the following quarter under normal market condition, while they freeze fringe area shops. The values of elasticity are 48% and -21% for the fringe area offices and fringe area shops, respectively. In contrast to the residential market results, all the explosive period dummies tend to be statistically significant and are negative in sign, suggesting that PR ratio growth slowed down in commercial sectors during explosive periods. Statistical significance of the interaction dummy coefficients is not strong. Yet, the interaction dummies are negative in sign, which is consistent with the earlier finding of the explosive period reverse spillover effects from the residential sector results. In fact, the interaction dummy coefficients are larger than those on ΔOC(-1) for most sectors. The influence of central area offices may have amplified during the development of explosive expansions.

3.4 Price or Rent?

In the preceding section, it was found that semi-detached sector drives the residential markets in PR ratios. This is, at first glance, puzzling because non-landed is by far the largest segment of Singapore's residential property market and the most common type of home in Singapore (according to the Singapore Department of Statistics, the market share of non-landed property is approximately 70% of all private properties). We now estimate impulse response for both price and rent of the residential market to investigate further the confounding dominance of the semi-detached sector. Figures 4c and 4d report the estimates. The first column of Figure 4c presents price responses of each sector to a semi-detached price shock. All residential sectors respond significantly for approximately 8 quarters. Even more illuminating are the responses to detached price shocks in the third column of the figure. All sectors show highly persistent (almost permanent) and significant responses; that is, the detached sector also drives residential prices.

For rents, the impulse responses point to non-landed properties as the driver. Figure 4d indicates that non-landed rent is the most influential. Semi-detached rent is less influential than non-landed. Little evidence is found for detached and terrace rents as a driving force.

These results motivate a re-estimation of the spillover regression (equation 8) with price and rent variables. Tables 5 and 6 present the estimates for prices and rents respectively. For prices, ΔNL(-1) is significant explaining ΔSEMI, which suggests that non-landed price growth affects semi-detached housing price growth in normal periods. During explosive periods, semi-detached price growth explains non-landed price growth in a larger magnitude (0.64).

The estimates in Table 6 confirm the rent driving force of non-landed. ΔNL(-1) is significant in all columns, while the interaction dummy, D*ΔNL(-1), also explains detached and semi rent growth. Overall, it appears that landed housing (semi-detached and detached) and non-landed housing play different roles in propagating price and rents shocks.

This dichotomy between prices and rents begs the question of whether prices or rents lead the other. Bi-variate impulse responses of prices and rents are estimated for individual market sector. Figures 3e-3n suggest that prices lead rents generally, while prices and rents interact for non-landed, office fringe, shop fringe and warehouse. Most salient is high persistence of price responses to rent for non-landed. Rent responses die out in 8 quarters but price responses stay significant almost permanently. These results are in harmony with the preceding findings that prices tend to drive the market for landed properties and rents are the driving force for non-landed properties.[12]

4 Conclusion

In a country like Singapore, where the government uses policy measures to stimulate or cool the property market, it is important to identify when high property prices are indeed indicating speculative bubbles. We set out to investigate this with the PSY procedure using rental against property prices and found that the Singapore property market is

[12] Approximately 90% of all landed properties such as semi-detached houses are owned by regular residents in Singapore. These properties may be less speculative in nature as the owners are likely to stay in the property long term. Approximately 30% of non-landed residents are non-residents; this combined with increase in the non-resident population creates may have increased demand for rents.

characterized by high corresponding rental prices. The key reason for the finding is due to the scarcity of rental properties such as the case of Singapore and Hong Kong. In such economies, rentals tend to drive the property market. Policy makers need to be mindful of this characteristic of the market when implementing cooling measures as rental prices may take longer to react to these policies. For example, sudden surge in rental could be due to population growth (or immigration). If these are indeed the cause of the "bubble" or explosive expansions of housing markets, policies directed at loan requirements may not be effective.

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Table 1 ADF Statistics

	ADF Statistics (p value)	Lag order
DET	-1.25 (0.66)	1
SEMI	-1.98 (0.30)	1
TER	-2.28 (0.19)	1
NL	-3.77 (0.01)	1
OC	-1.58 (0.49)	2
OF	-1.45 (0.56)	1
SC	-1.85 (0.36)	1
SF	-2.22 (0.21)	1
FAC	-0.97 (0.77)	1
WH	-1.62 (0.47)	2

Notes: Results from use of ADF test regression including a constant and linear time trend; based on full sample of 1998Q4 to 2014Q3. Lag order is determined by testing-down from a maximum of four lags using a t-test for the significance of last lag (5 percent level). At a minimum one lag is included in the ADF test regression. P values are in parentheses.

Table 2 The GSADF Statistics and Date Stamping Estimates

	GSADF			Date Stamping for P/R		
Residential	P	R	P/R	Start	End	Duration (Quarters)
DET	2.67*	1.47	1.77	Jun, 2008	Sep, 2008	2
				Mar, 2009	Jun, 2009	2
SEMI	1.73	2.40*	3.90*	Sep, 2007	Dec, 2008	6
TER	1.65	2.32*	4.53*	Sep, 2006	Jun, 2009	12
NL	4.64*	1.05	2.09*	Mar, 2009	Jun, 2009	2
Commercial						
OC	1.52	1.23	5.92*	Jun, 2006	Mar, 2009	12
OF	1.52	2.43*	2.00*	Dec, 2006	Sep, 2008	8
				Mar, 2009	Jun, 2009	2
SC	0.97	2.00	0.19			
SF	1.00	1.43	-0.01			
FAC	0.89	2.53*	2.00*	Sep, 2012	Sep, 2012	1
WH	0.98	1.74	2.17*	Mar, 2008	Jun, 2008	2
				Jun, 2012	Sep, 2012	2
				Mar, 2013	Sep, 2013	3

Note: P, R and PR denote real Price, real Rent and PR ratio in log, respectively. Critical values for the GSADF tests are 2.57 (1%), 1.92 (5%) and 1.59 (10%). Lag order of 1 and the minimum window of 20 observations are chosen for both GSADF regressions and BSADF regressions. Asterisks indicate significance at the 5% level (or higher) based on critical values derived from 2000 simulations. Date stamping estimates are obtained from the BSADF statistics at the 5% level based on critical values derived from 2000 simulations.

Table 3 Sectorial Spill Over for Residential Markets

	ΔDET	ΔDET	ΔTER	ΔTER	ΔNL	ΔSEMI
ΔDET(-1)	-0.14 (0.42)	0.06 (0.74)				
ΔTER(-1)			0.30* (0.07)	0.45* (0.02)		
ΔSEMI(-1)	0.31* (0.11)		0.18 (0.30)		0.36* (0.08)	0.41* (0.03)
ΔNL(-1)		0.33* (0.11)		-0.02 (0.89)	0.08 (0.63)	0.05 (0.76)
D	0.00 (0.20)	0.00 (0.28)	0.00 (0.95)	0.00 (0.97)	0.01 (0.91)	0.12 (0.44)
D*ΔSEMI(-1)	-0.18* (0.15)		0.00 (0.59)		-0.01 (0.87)	
D*ΔNL(-1)		-0.20 (0.76)		0.60 (0.35)		-0.09 (0.42)
Adjusted R-squared	0.22	0.22	0.30	0.30	0.30	0.31
Durbin-Watson stat	2.02	2.02	1.87	1.77	2.02	2.05
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00

Note: Δ and D denote first difference and dummay, respectively. P values are in parentheses. An asterisk indicates statistical significance at a reasonable level.

Table 4 Sectorial Spill Over for Commercial Markets

	ΔOF	ΔSC	ΔSF	ΔFAC	ΔWH
ΔOF(-1)	-0.37* (0.00)				
ΔSC(-1)		0.32* (0.02)			
ΔSF(-1)			-0.01 (0.92)		
ΔFAC(-1)				0.09 (0.47)	
ΔWH(-1)					-0.05 (0.68)
ΔOC(-1)	0.48* (0.01)	-0.12 (0.40)	-0.21* (0.07)	-0.07 (0.42)	0.08 (0.35)
D	-0.01* (0.08)	-0.01* (0.05)	-0.01* (0.00)	-0.01* (0.13)	-0.01* (0.00)
D*ΔOC(-1)	-0.19 (0.69)	-0.25 (0.50)	0.12 (0.68)	-0.33 (0.20)	-0.26 (0.29)
Adjusted R-squared	0.19	0.16	0.12	0.01	0.10
Durbin-Watson stat	2.05	2.03	1.94	2.06	2.01
Prob(F-statistic)	0.01	0.00	0.01	0.33	0.04

Note: Δ and D denote first difference and dummay, respectively. P values are in parentheses. An asterisk indicates statistical significance at a reasonable level.

Table 5 Sectorial Spill Over for Residential Markets (Prices)

	ΔDET	ΔDET	ΔTER	ΔTER	ΔNL	ΔSEMI
ΔDET(-1)	0.50* (0.03)	0.61* (0.01)				
ΔTER(-1)			0.54* (0.01)	0.53* (0.02)		
ΔSEMI(-1)	0.07 (0.76)		0.06 (0.78)		0.11 (0.67)	0.13 (0.59)
ΔNL(-1)		-0.06 (0.80)		0.07 (0.74)	0.39* (0.13)	0.44* (0.08)
D	0.00 (0.40)	0.00 (0.36)	0.00 (0.56)	0.00 (0.53)	0.00 (0.55)	0.00 (0.37)
D*ΔSEMI(-1)	0.00 (0.37)		0.27 (0.32)		0.64* (0.10)	
D*ΔNL(-1)		0.25 (0.22)		0.10 (0.59)		-0.08 (0.68)
Adjusted R-squared	0.40	0.40	0.40	0.40	0.37	0.33
Durbin-Watson stat	1.62	1.60	1.64	1.62	1.42	1.52
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00

Note: Δ and D denote first difference and dummay, respectively. P values are in parentheses. An asterisk indicates statistical significance at a reasonable level.

Table 6 Sectorial Spill Over for Residential Markets (Rents)

	ΔDET	ΔDET	ΔTER	ΔTER	ΔNL	ΔSEMI
ΔDET(-1)	0.35* (0.10)	-0.18 (0.38)				
ΔTER(-1)			0.21 (0.41)	-0.43* (0.02)		
ΔSEMI(-1)	-0.02 (0.93)		0.15 (0.60)		-0.78* (0.00)	-0.04 (0.82)
ΔNL(-1)		0.47* (0.04)		0.72* (0.00)	1.12* (0.00)	0.34* (0.10)
D	0.00 (0.97)	0.00 (0.87)	0.00 (0.24)	0.00* (0.12)	0.00 (0.75)	0.00 (0.62)
D*ΔSEMI(-1)	0.51* (0.02)		0.27 (0.23)		0.27 (0.61)	
D*ΔNL(-1)		0.44* (0.01)		0.25 (0.40)		0.44* (0.00)
Adjusted R-squared	0.42	0.57	0.34	0.57	0.67	0.59
Durbin-Watson stat	1.60	1.62	1.79	1.80	1.51	1.80
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00

Note: Δ and D denote first difference and dummay, respectively. P values are in parentheses. An asterisk indicates statistical significance at a reasonable level.

Figure 1: Population of Singapore (Reisdent and non-resident)

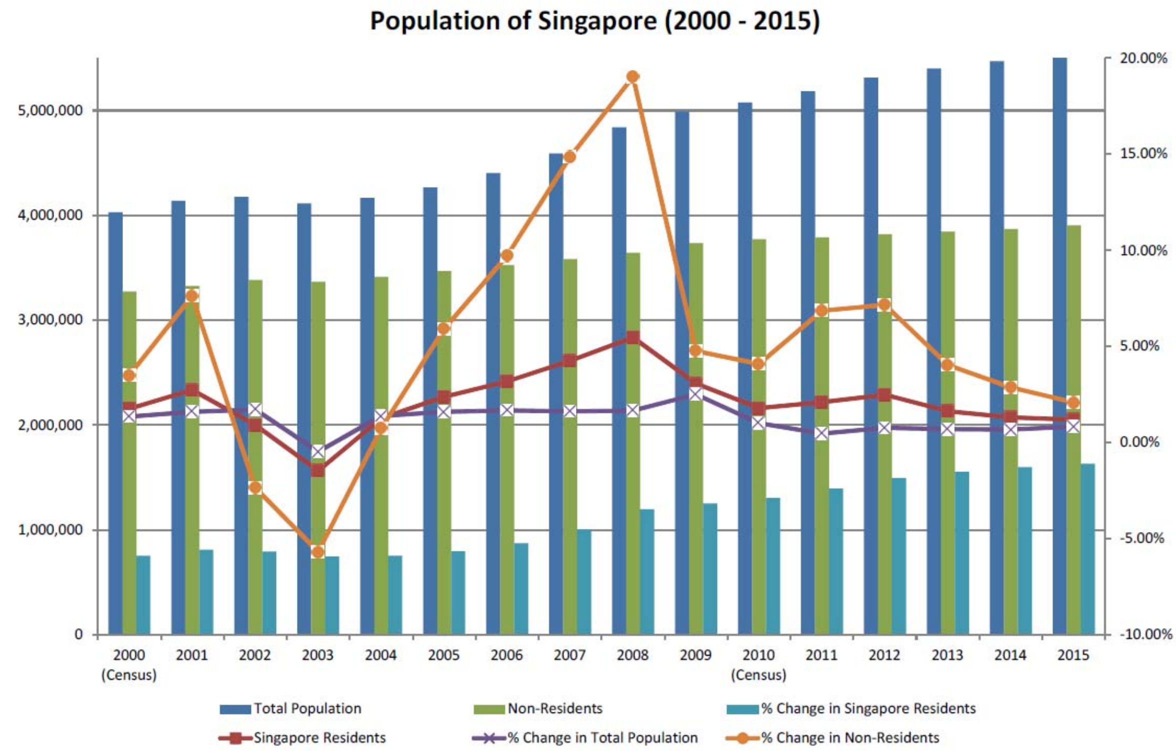

Figure 2: Median Price, Median Rent and PR ratio for Non-landed (NL) Housing

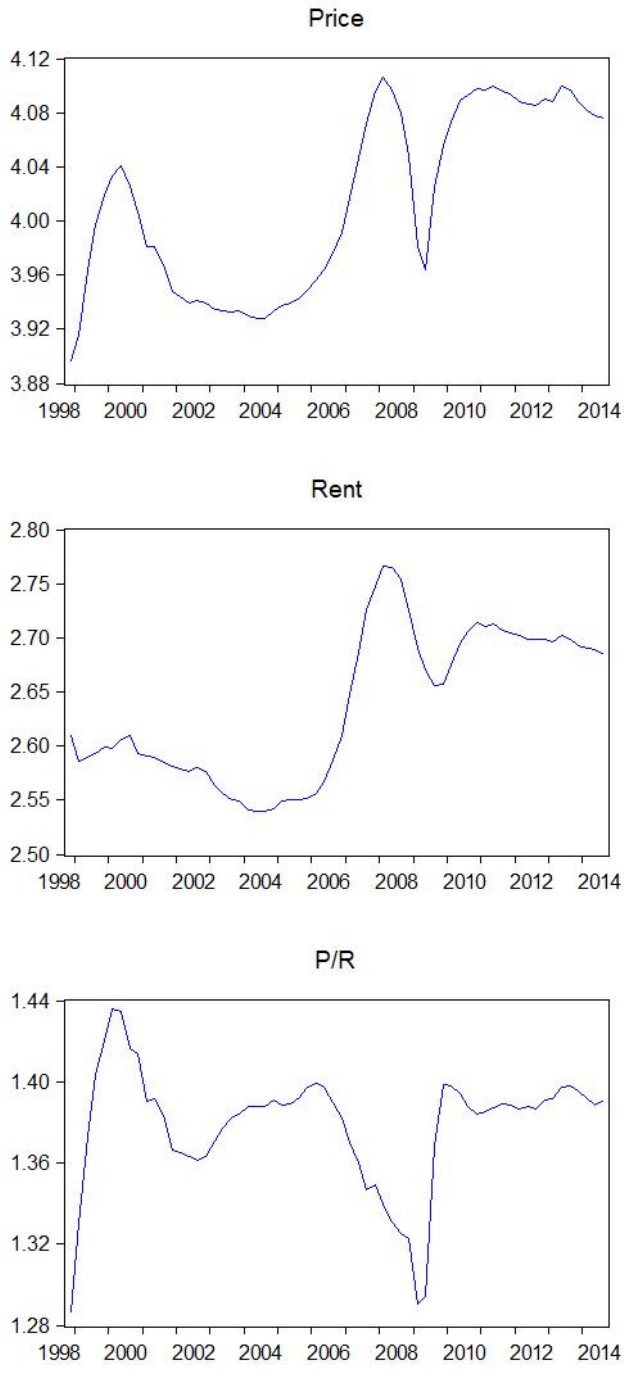

Figure 3a: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Detached (DET)

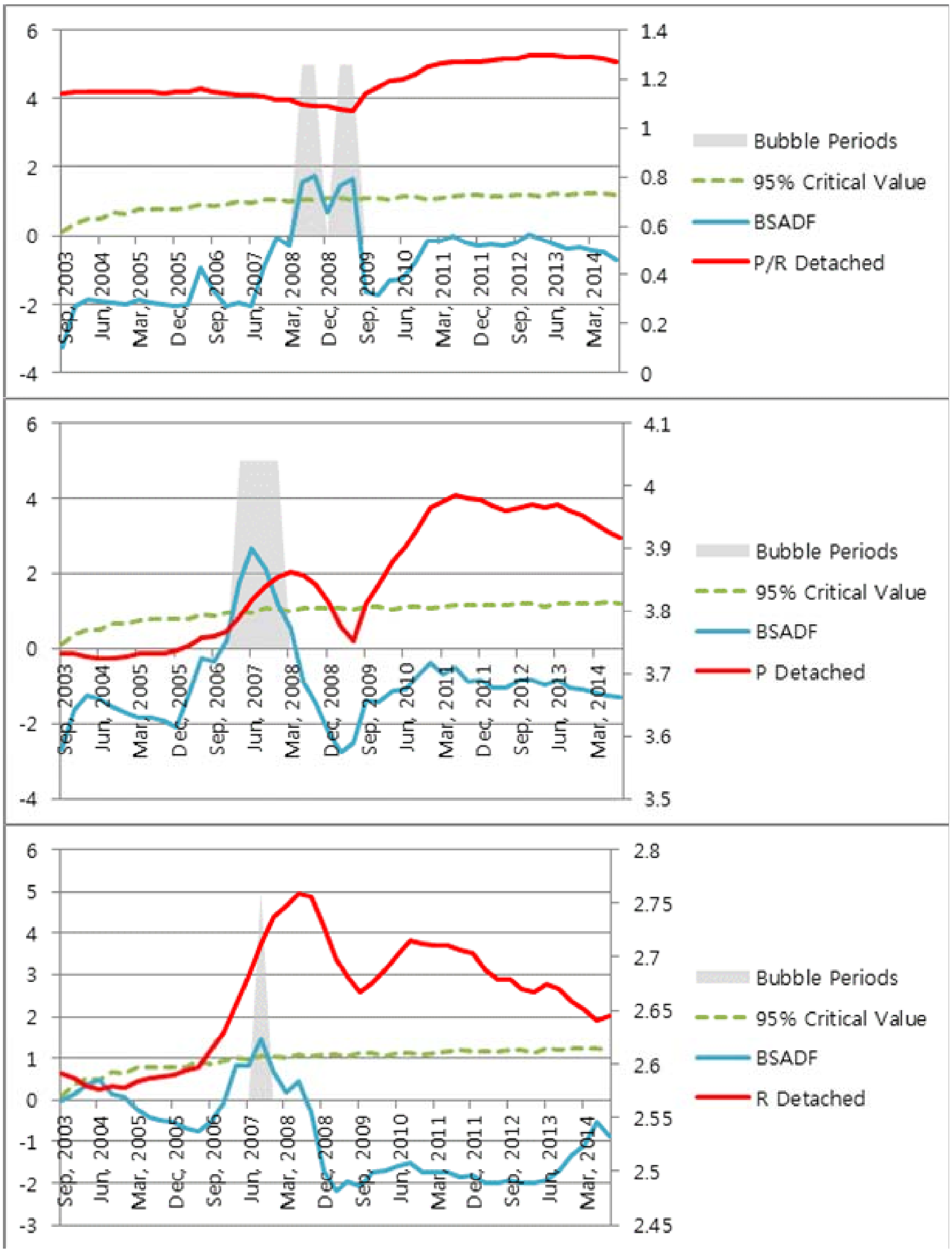

Figure 3b: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Semi-Detached (SEMI)

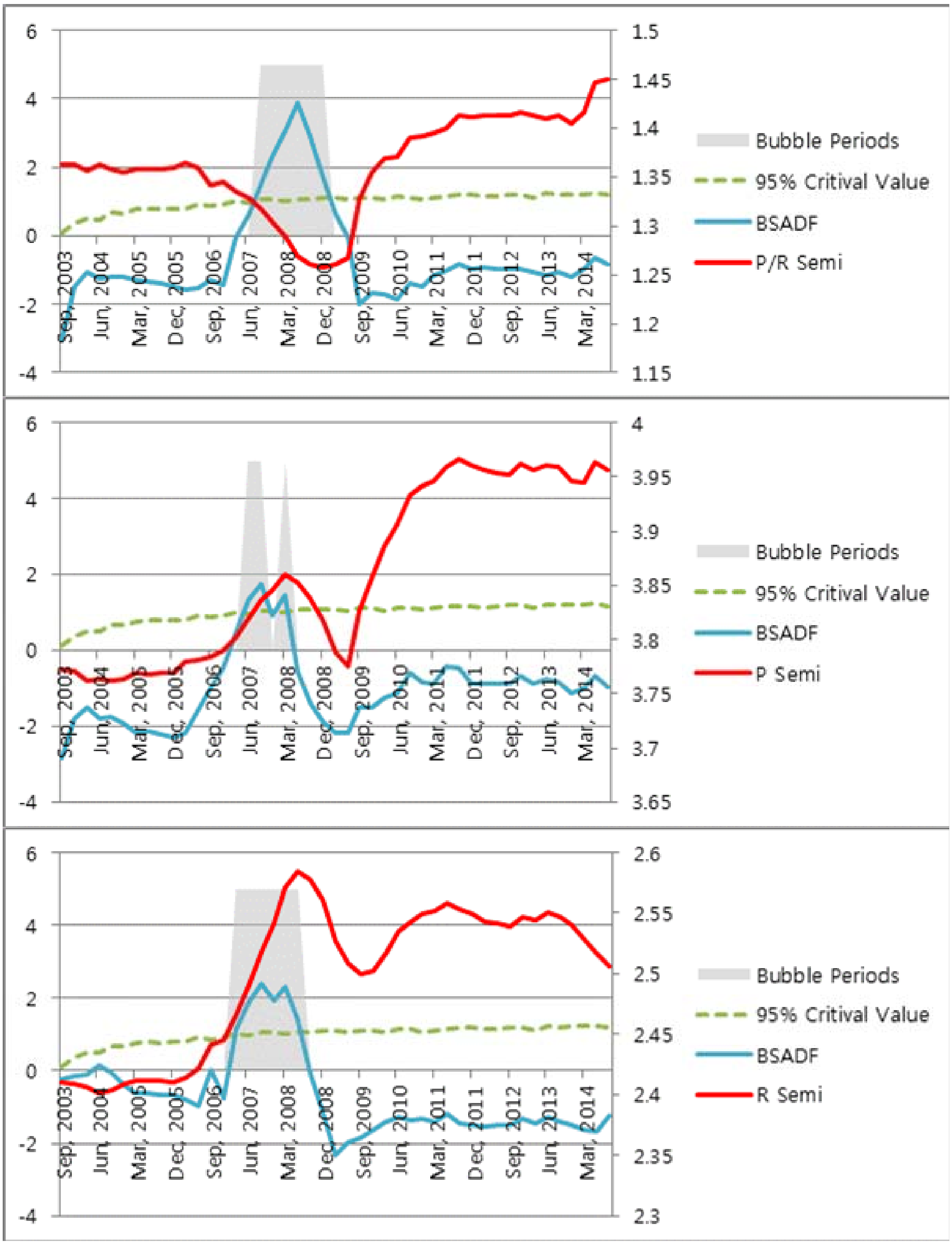

Figure 3c: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Terrace (TER)

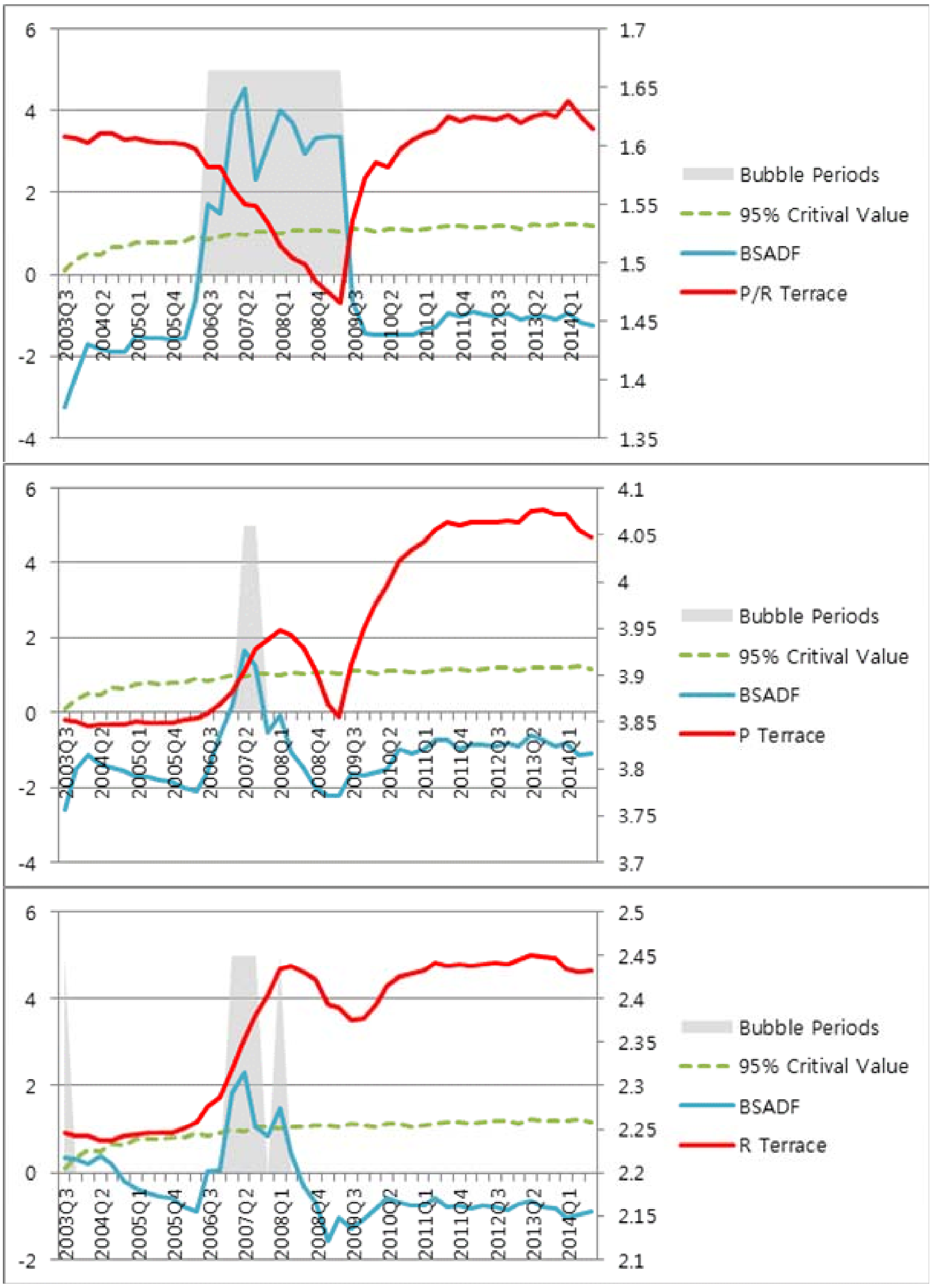

Figure 3d: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Nonlanded (NL)

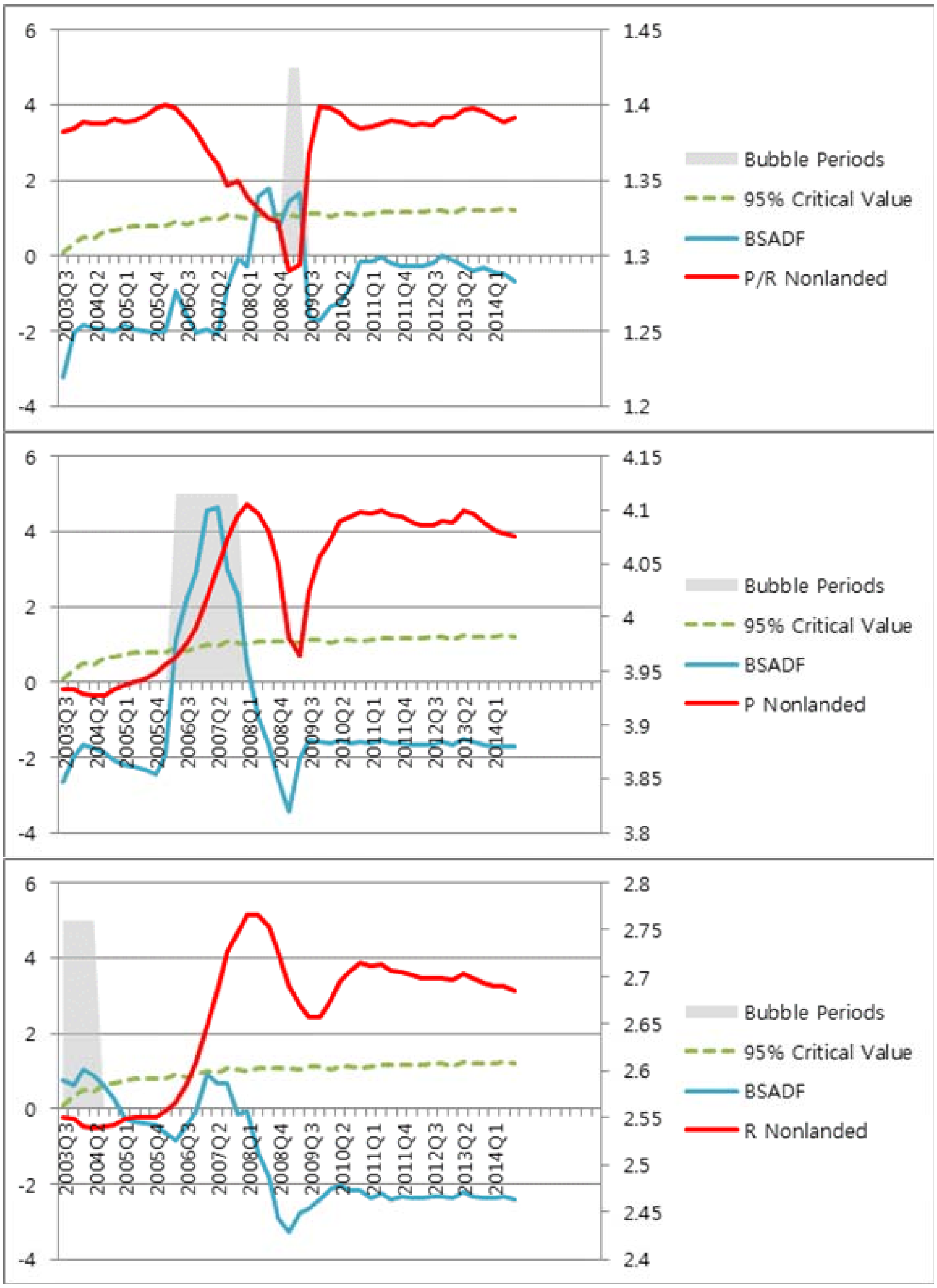

Figure 3e: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Office Central (OC)

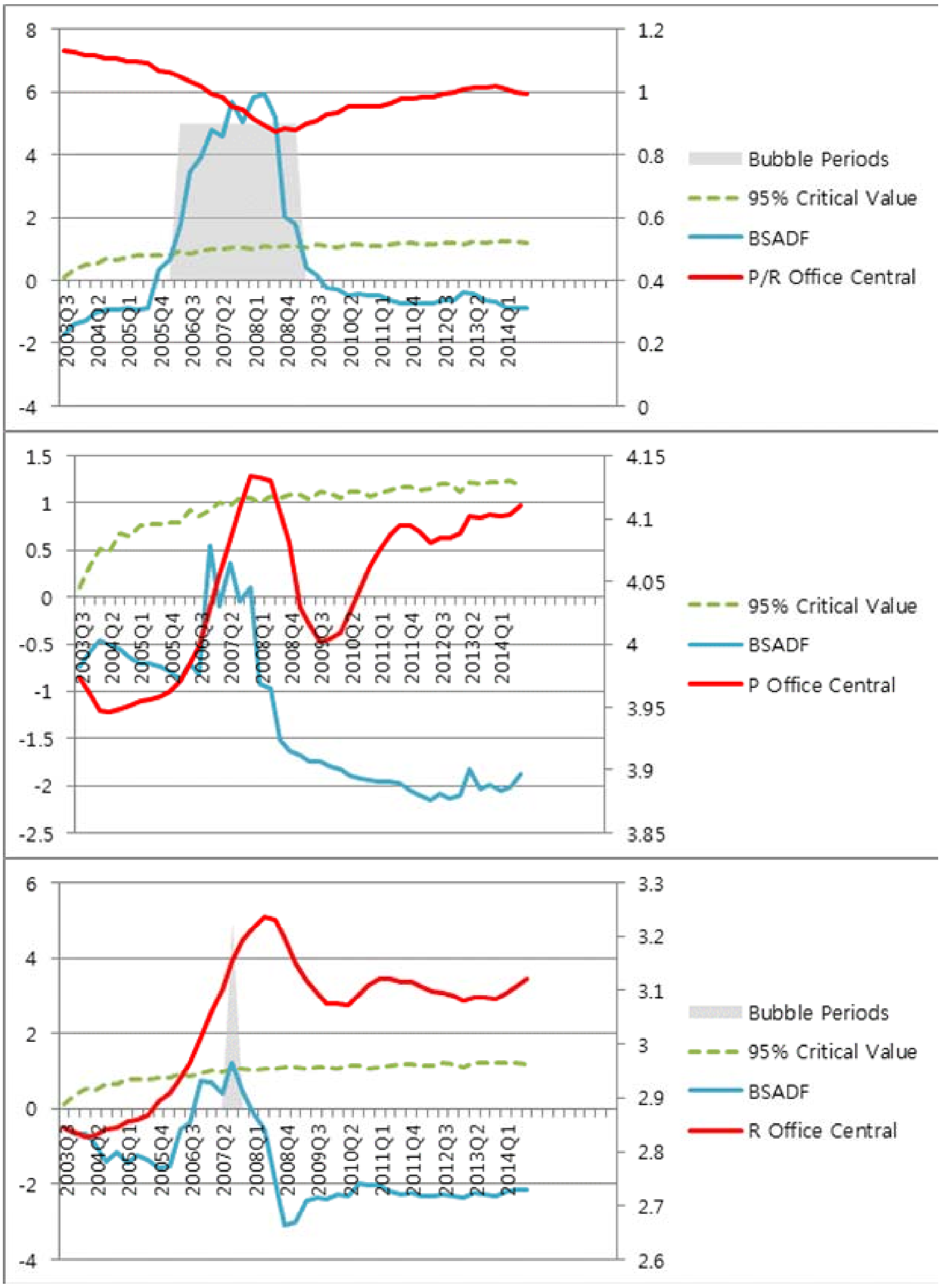

Figure 3f: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Office Fringe (OF)

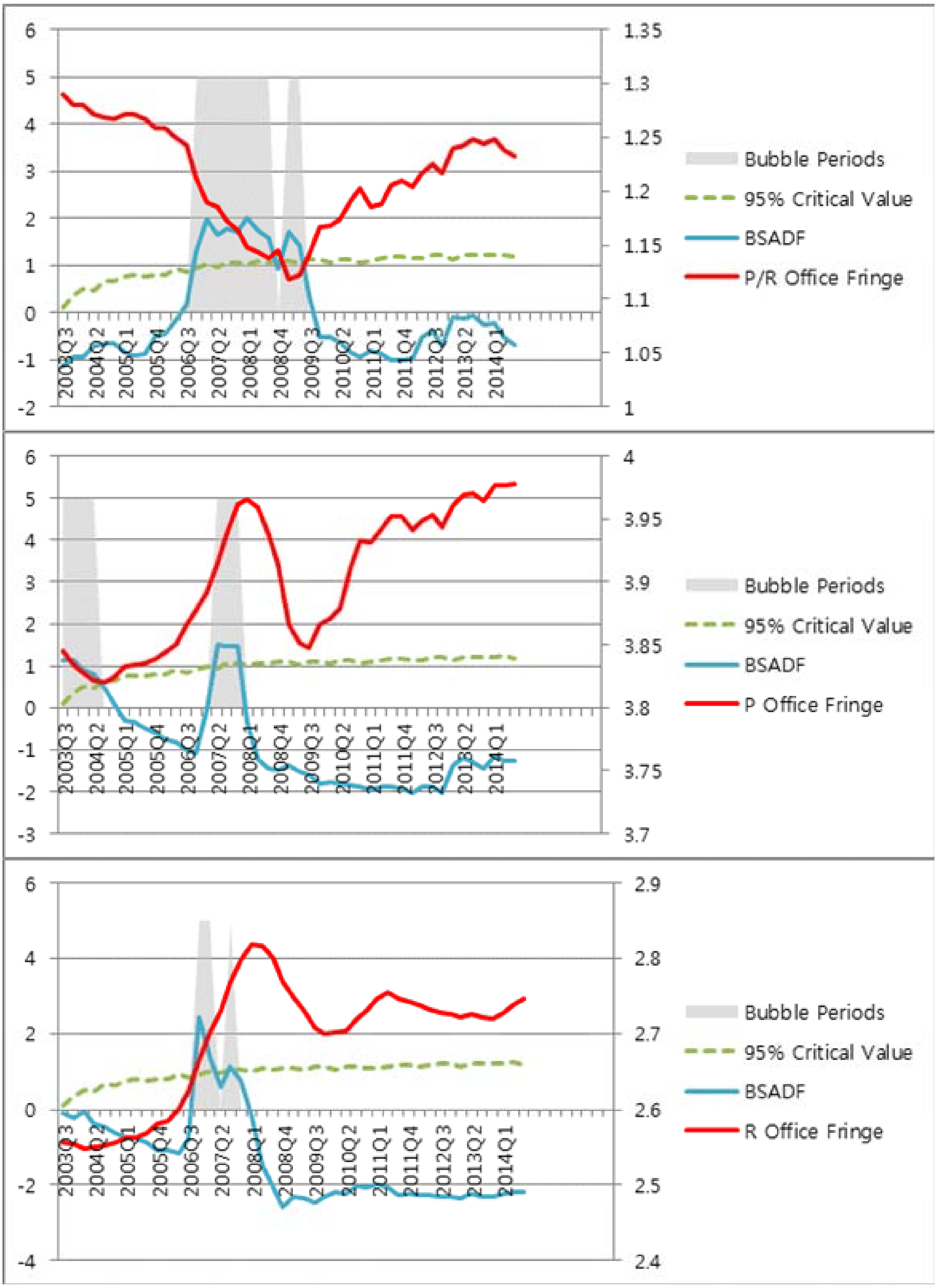

Figure 3g: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Shop Central (SC)

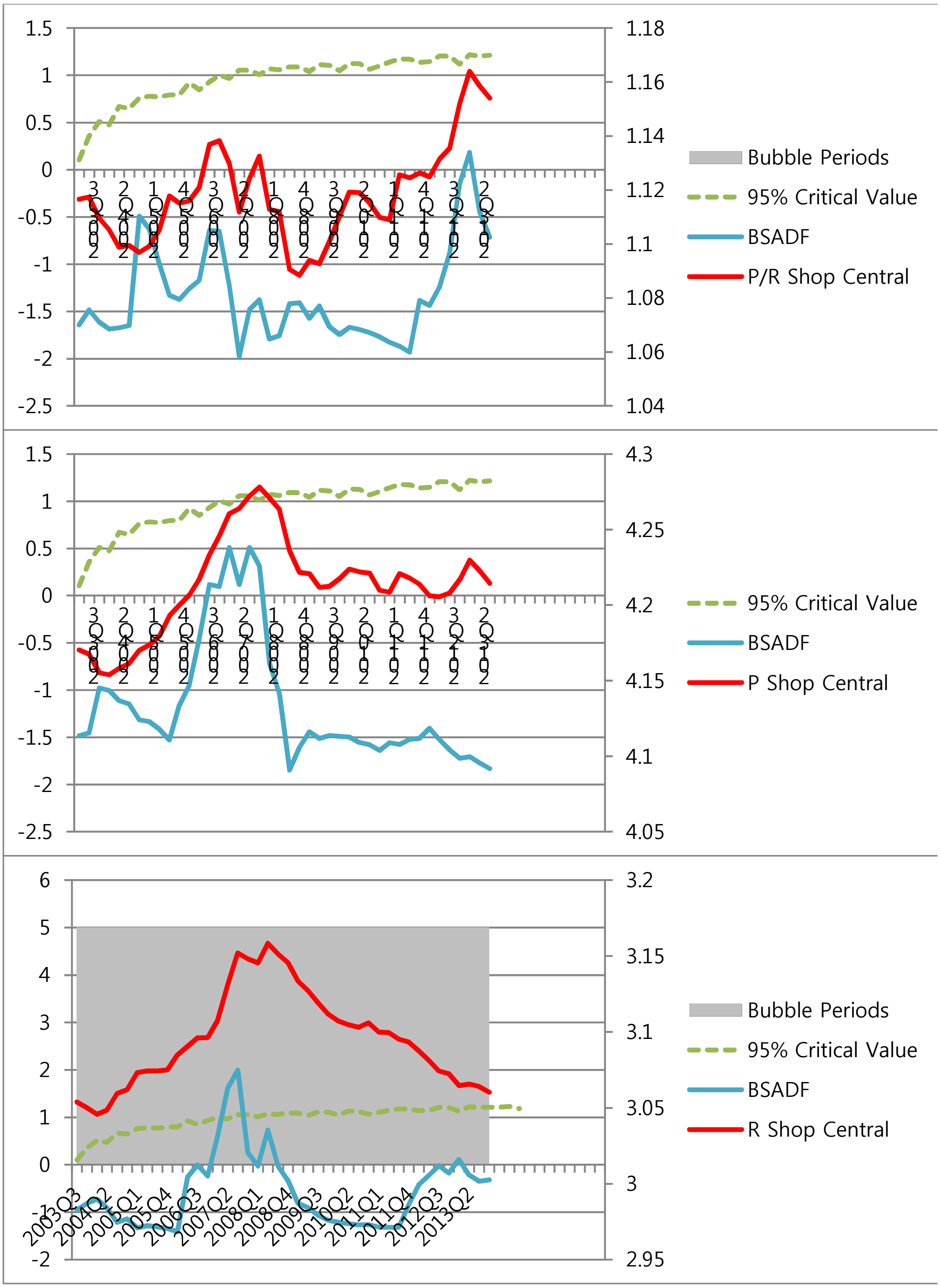

Figure 3h: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Shop Fringe (SF)

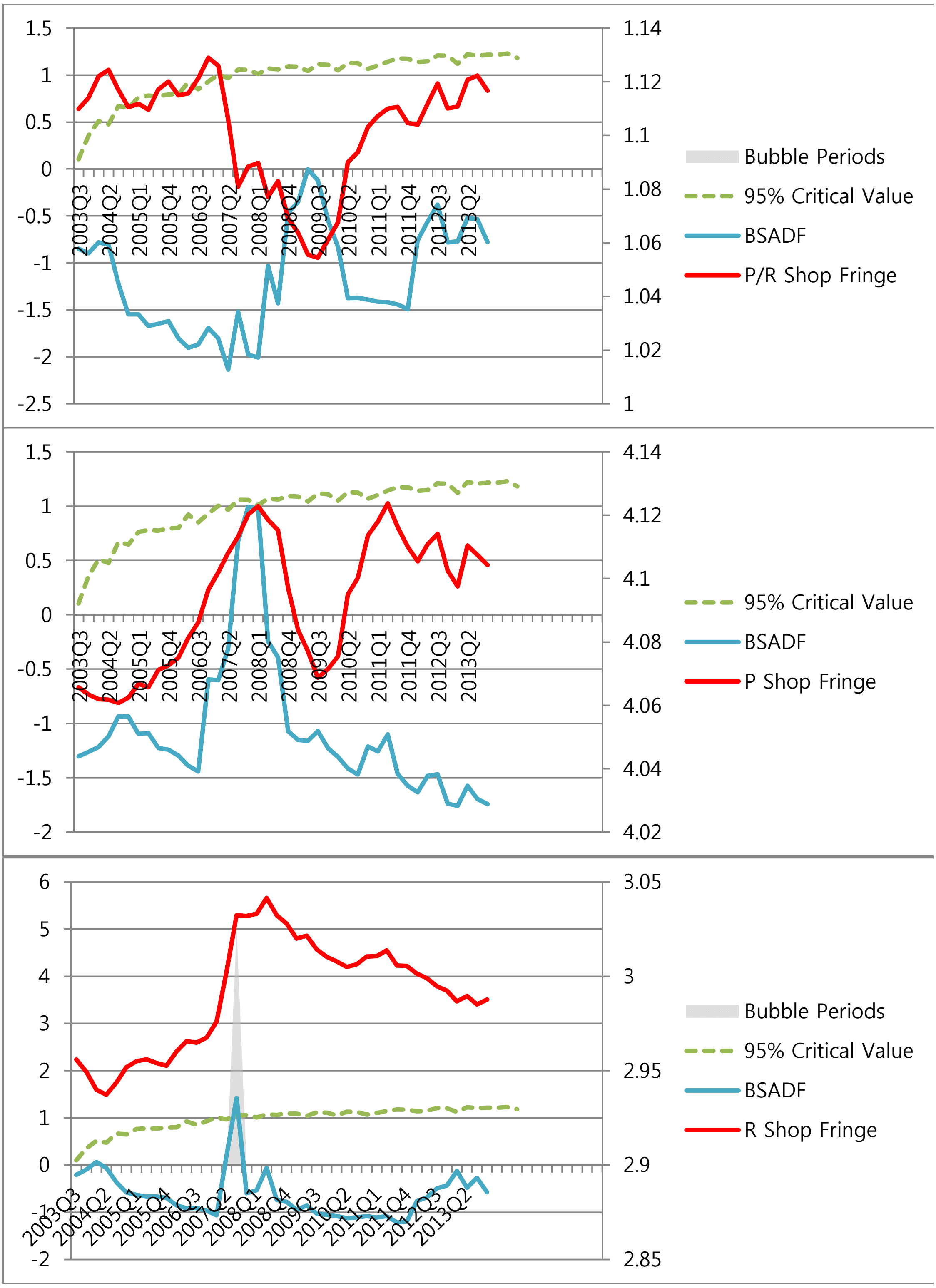

Figure 3i: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Factory (FAC)

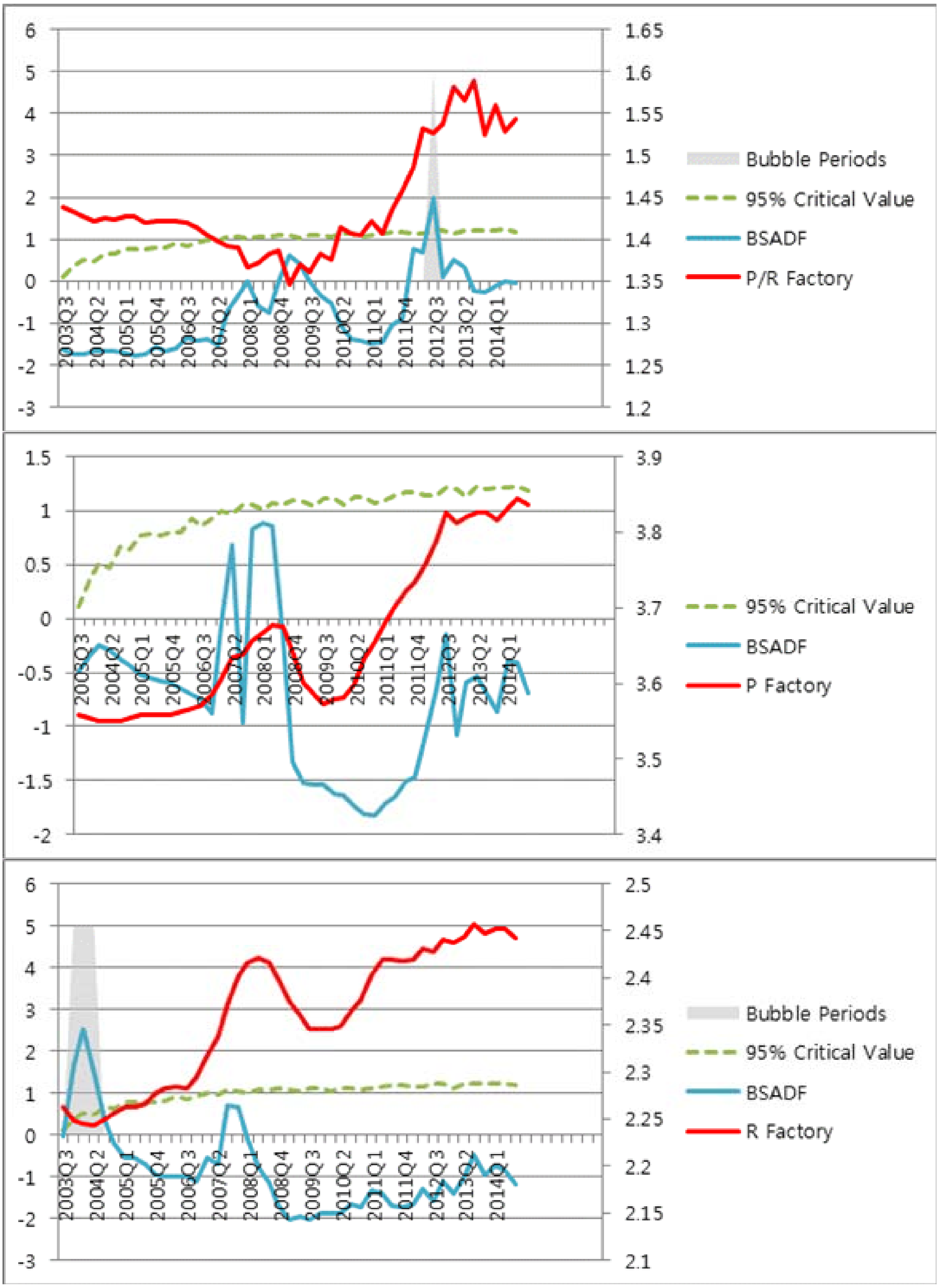

Figure 3j: P/R ratios, price and rent with their BSADF statistics and the 95% critical values for Warehouse (WH)

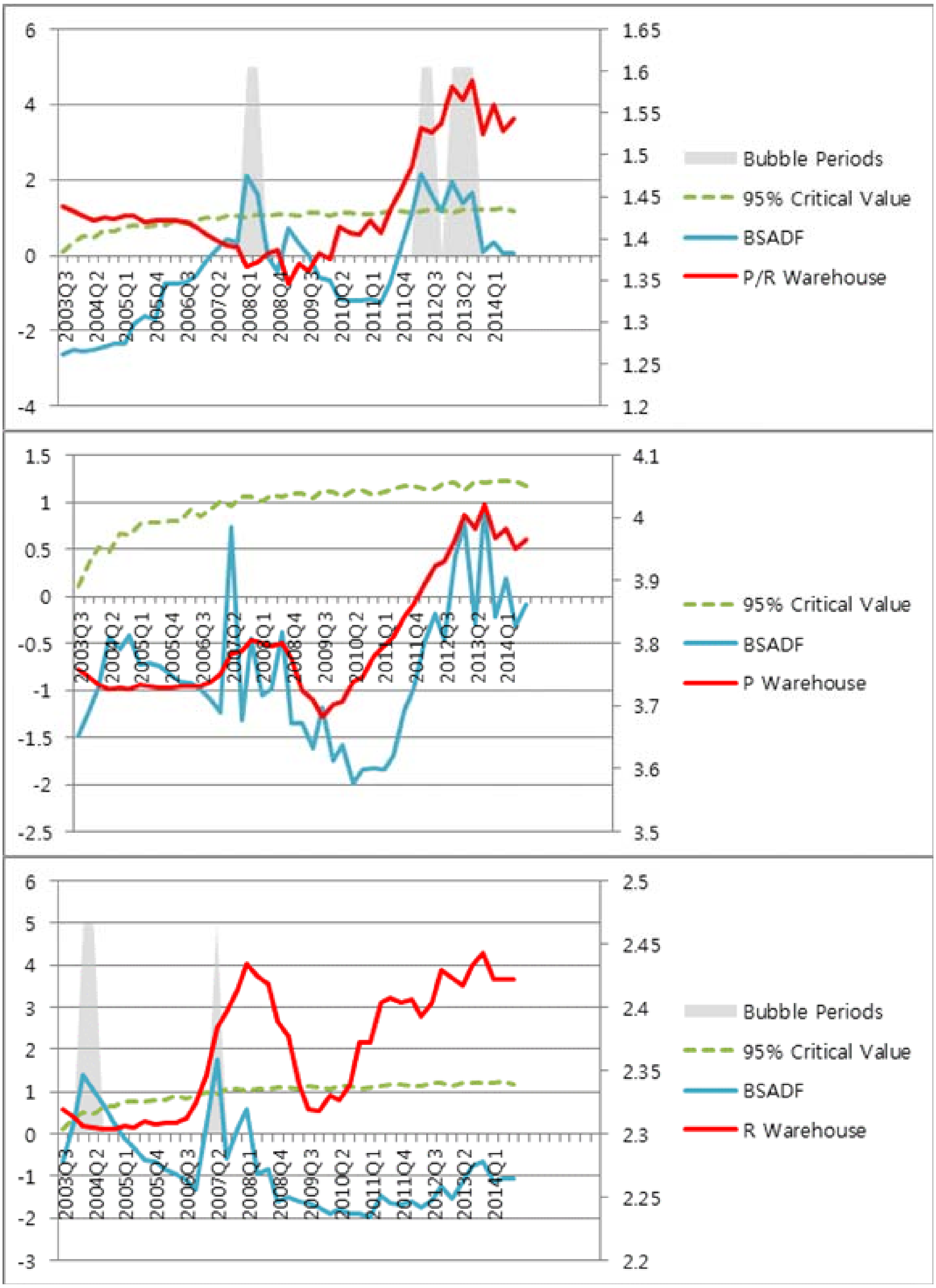

Figure 4a: Impulse responses for residential market (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

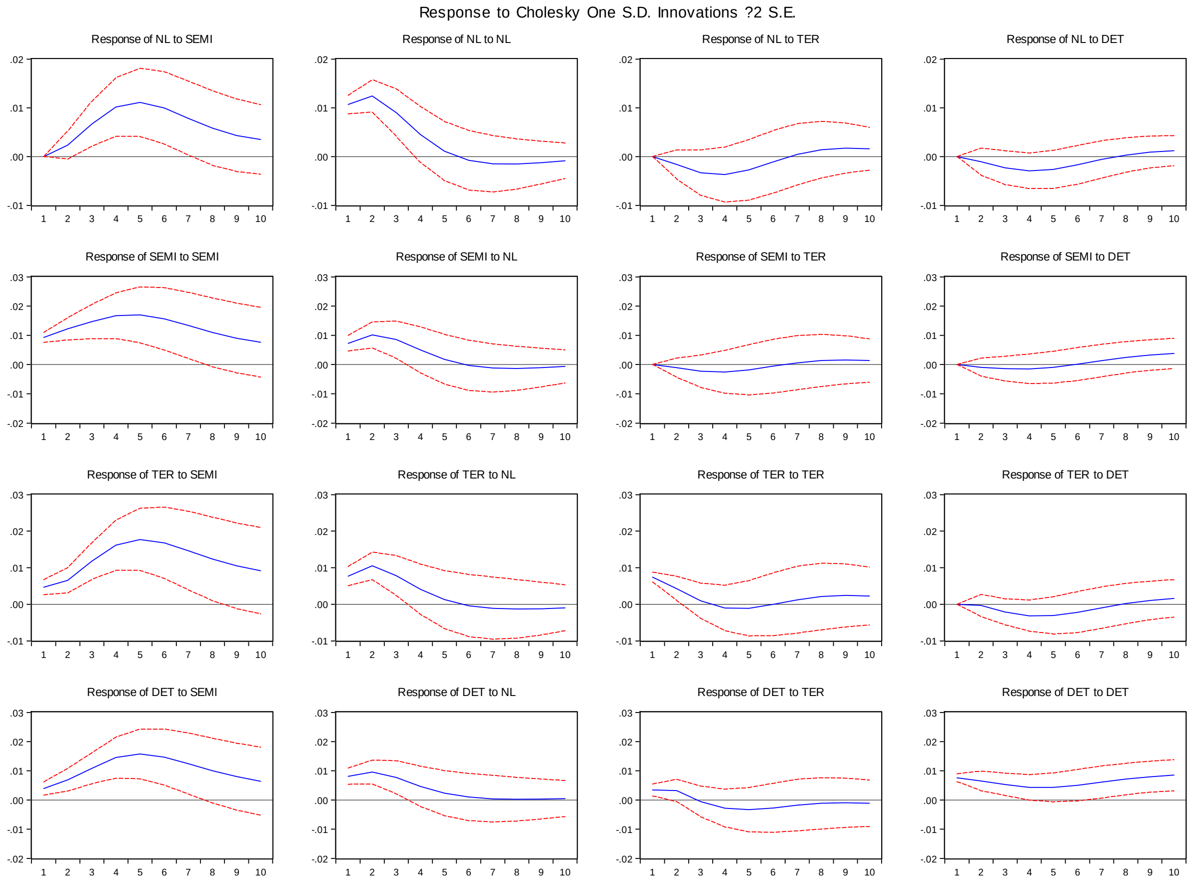

Figure 4b: Impulse responses for commercial market (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

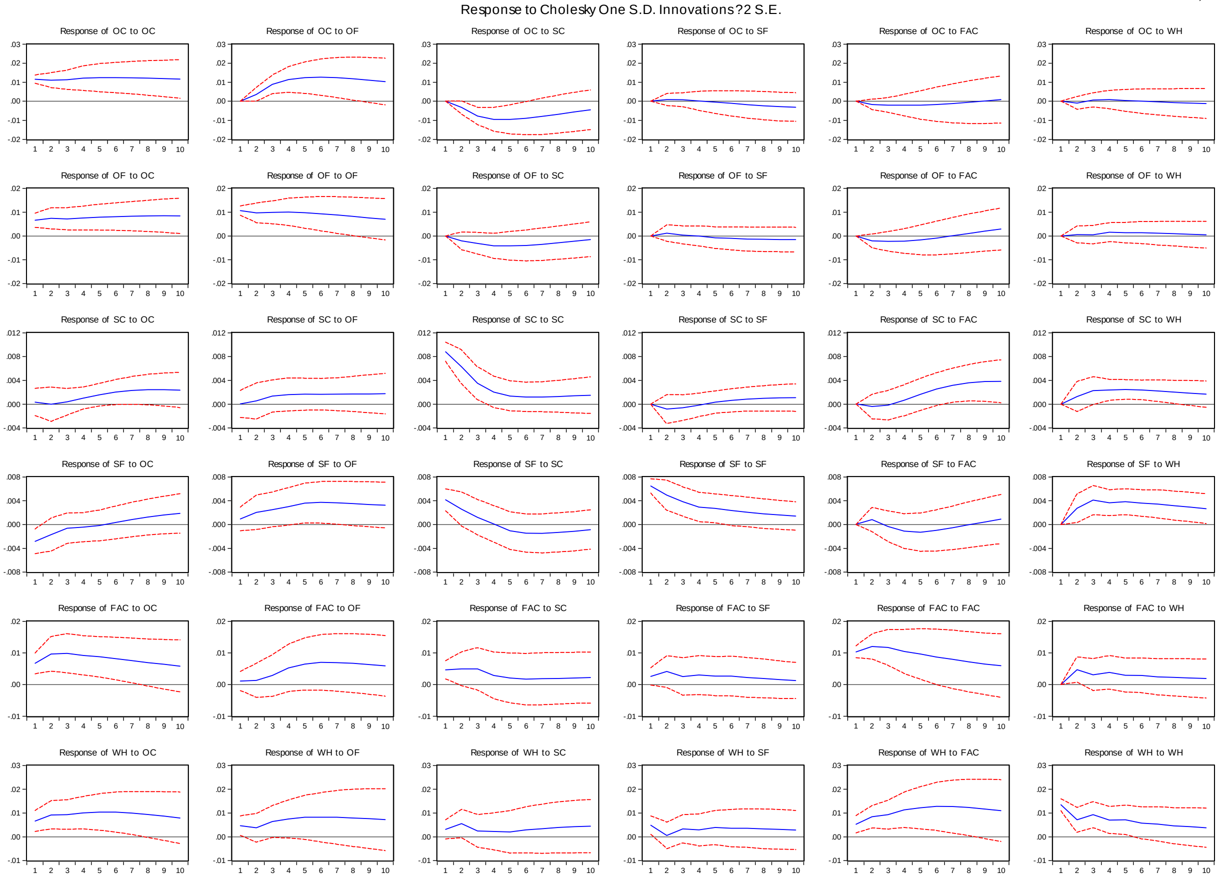

Figure 4c: Impulse responses for residential prices (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

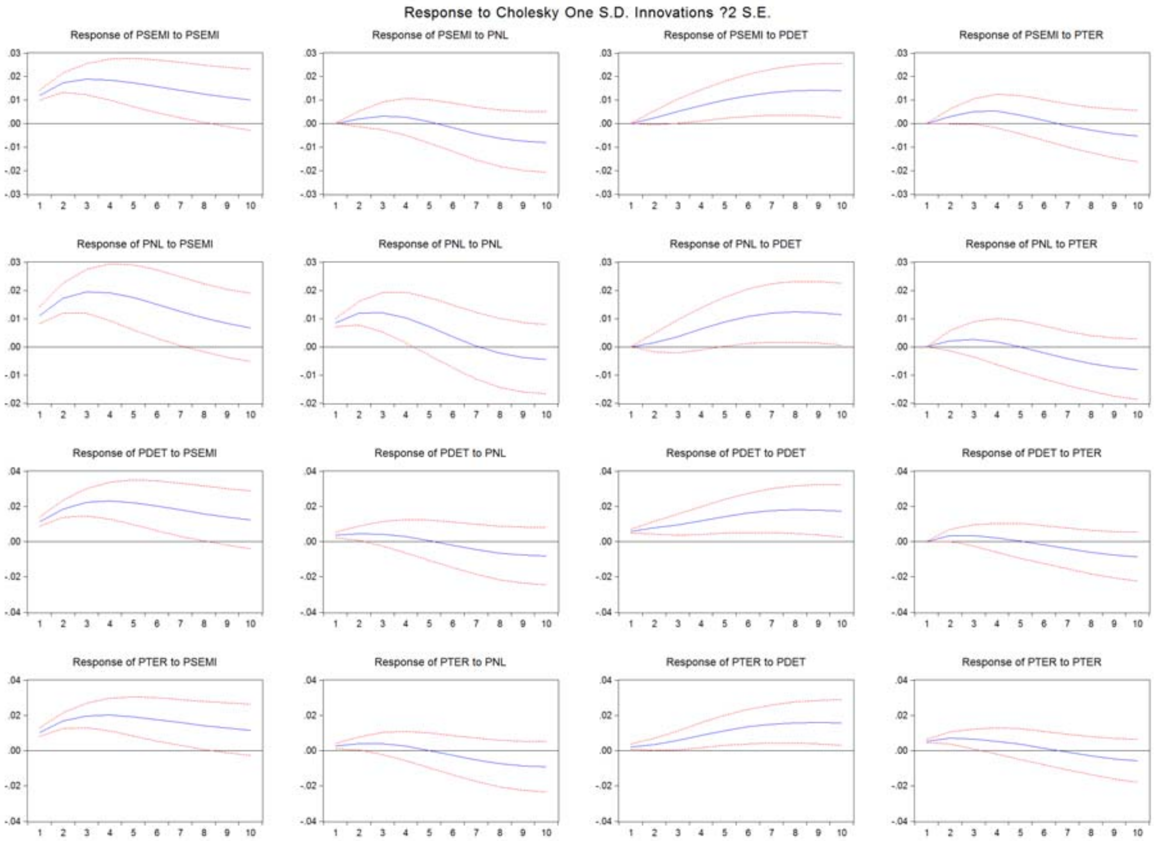

Figure 4d: Figure 7d: Impulse responses for residential rents (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

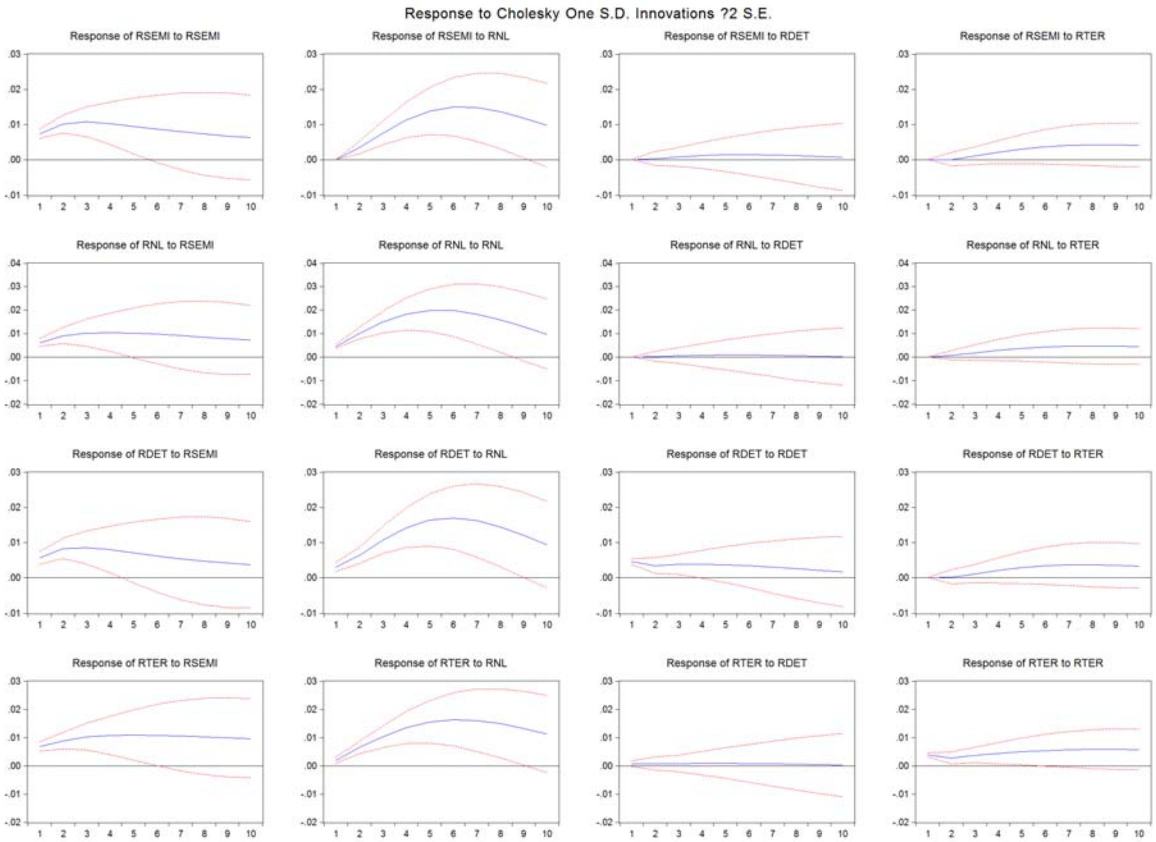

Figure 4e: Impulse responses for detached (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

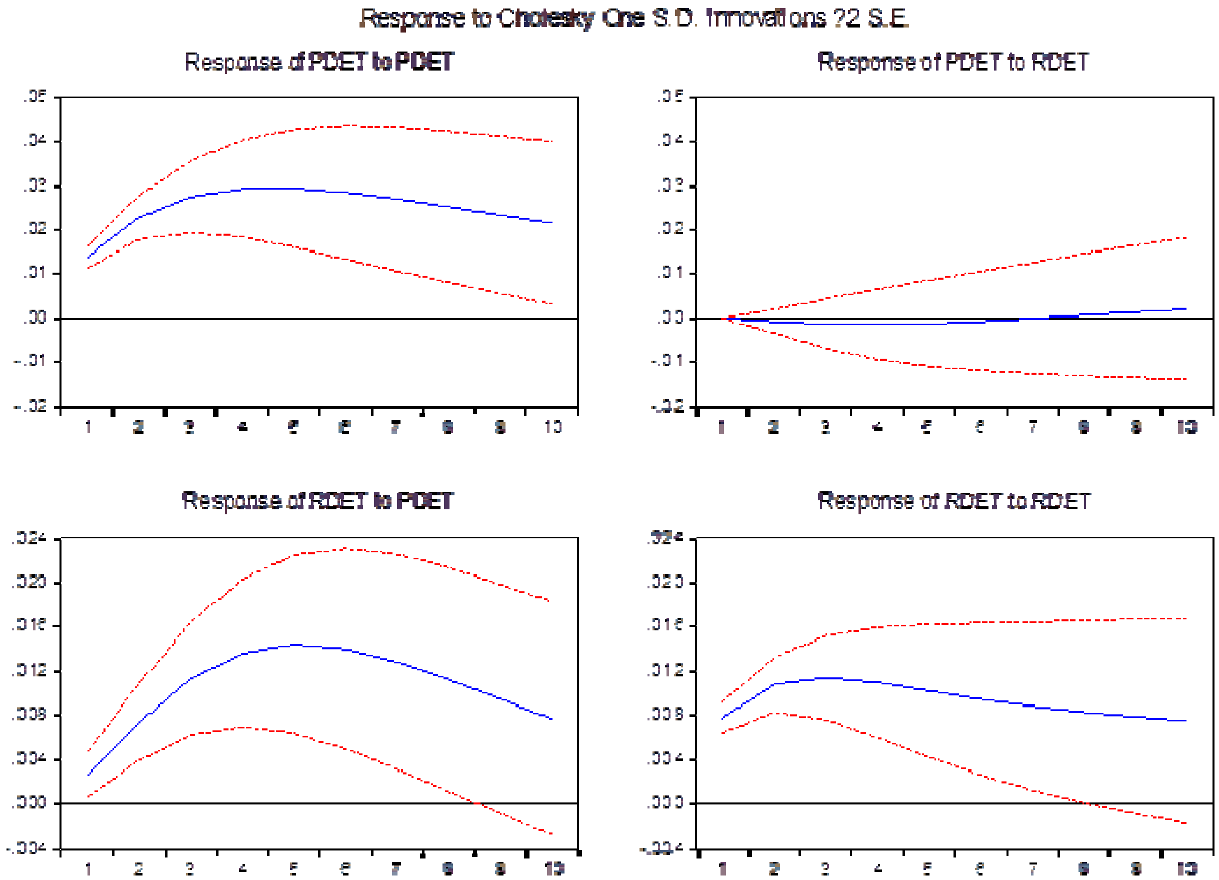

Figure 4f: Impulse responses for semi-detached (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

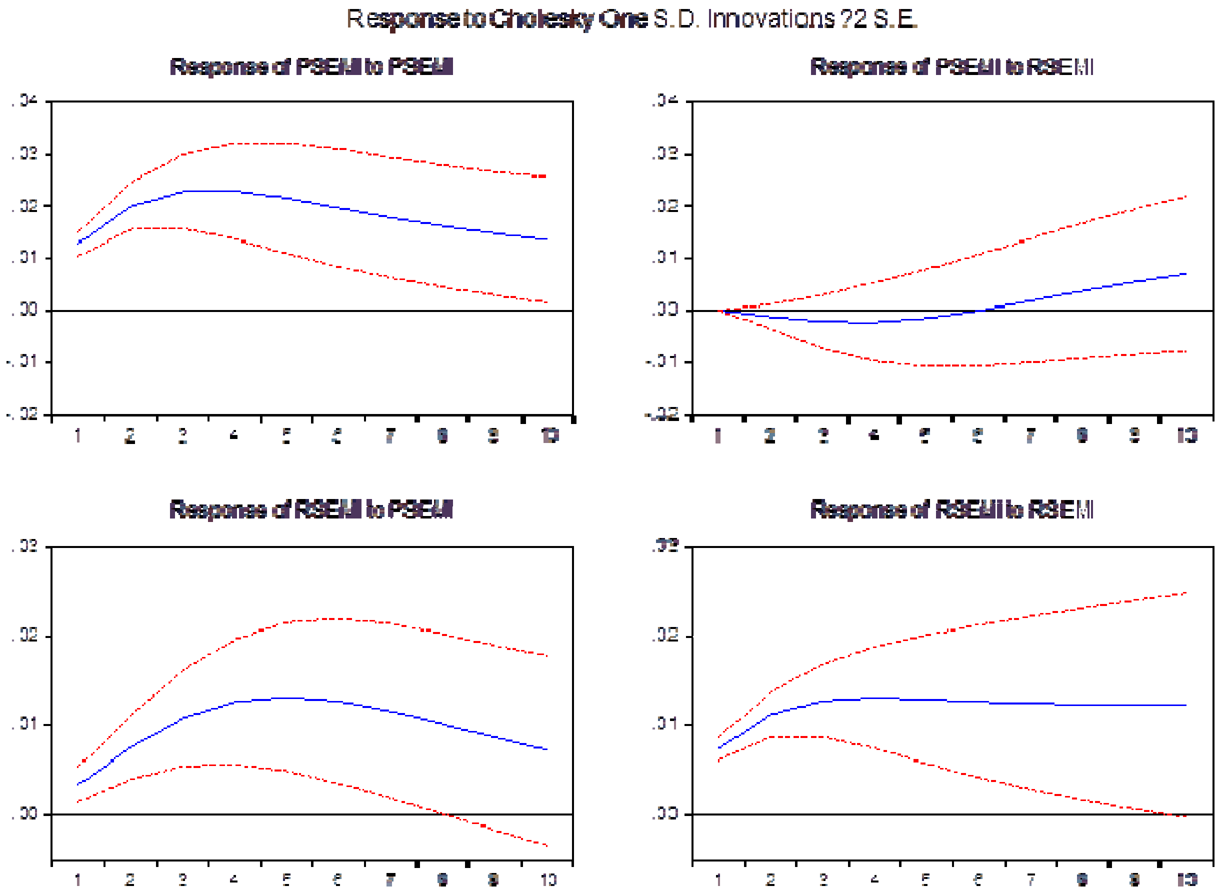

Figure 4g: Impulse responses for terrace (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

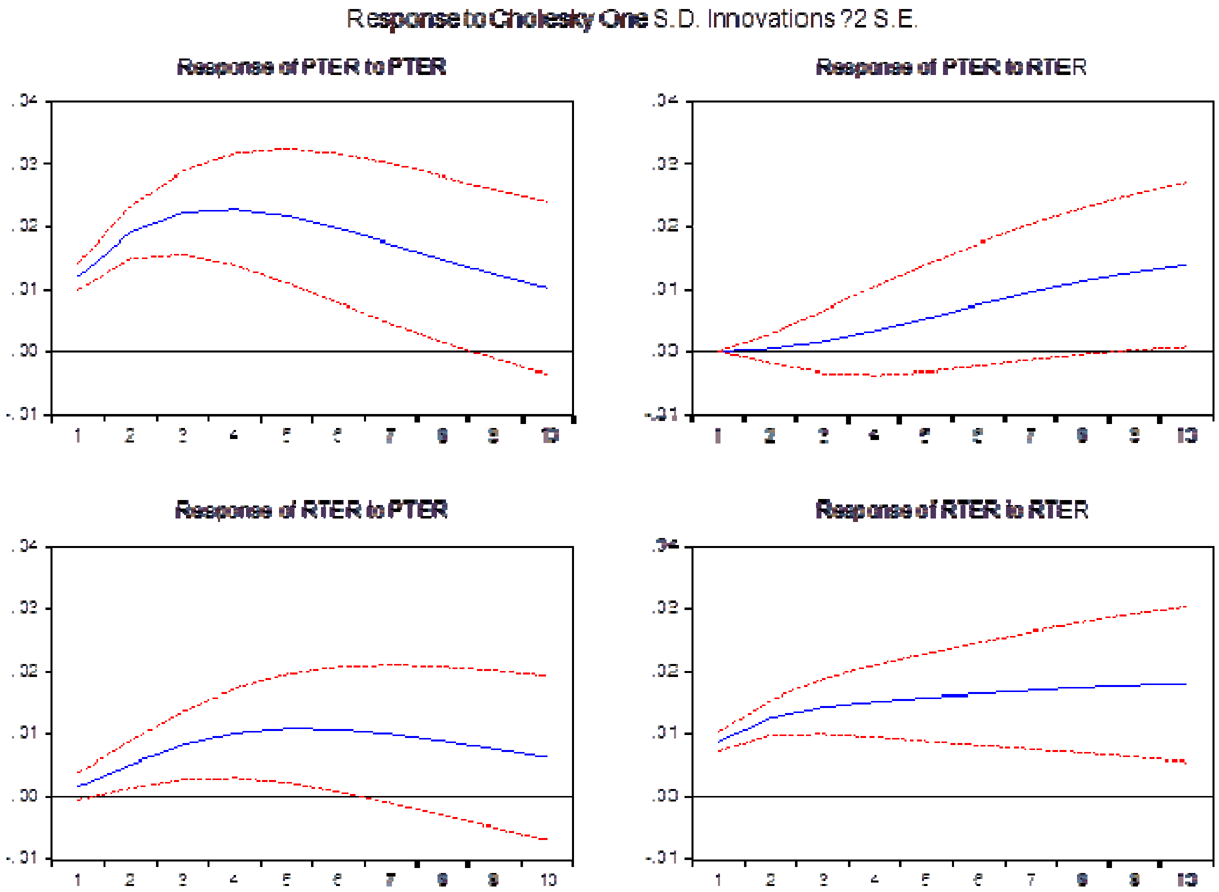

Figure 4h: Impulse responses for non-landed (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

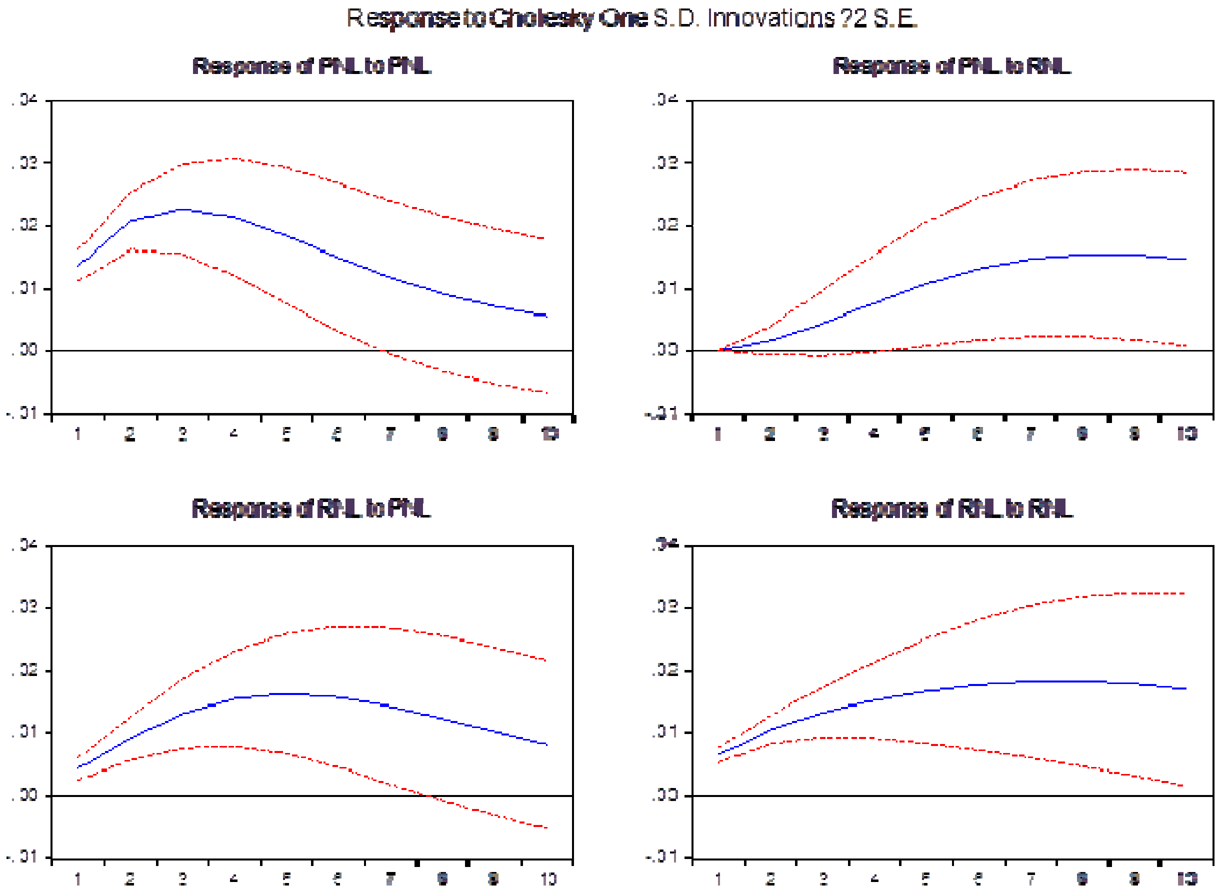

Figure 4i: Impulse responses for office central (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

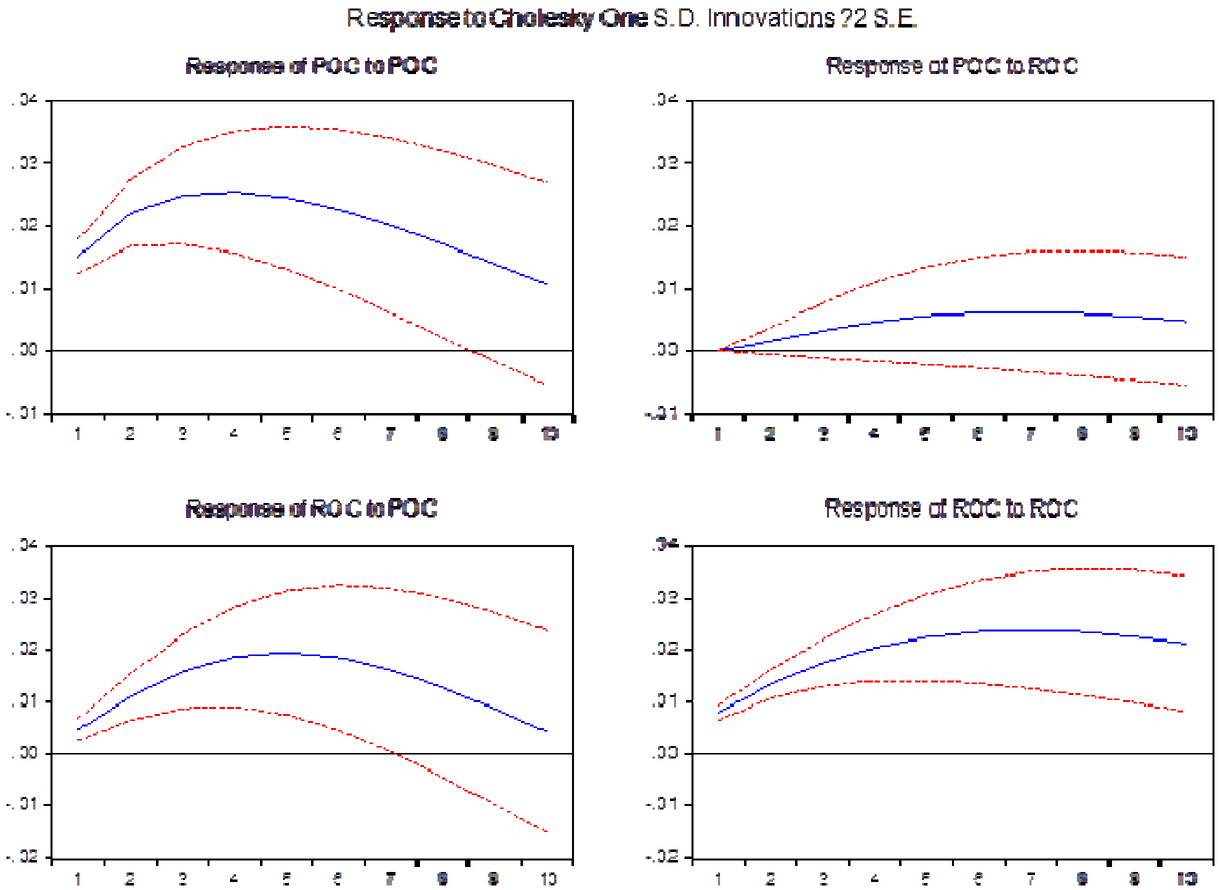

Figure 4j: Impulse responses for office fringe (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

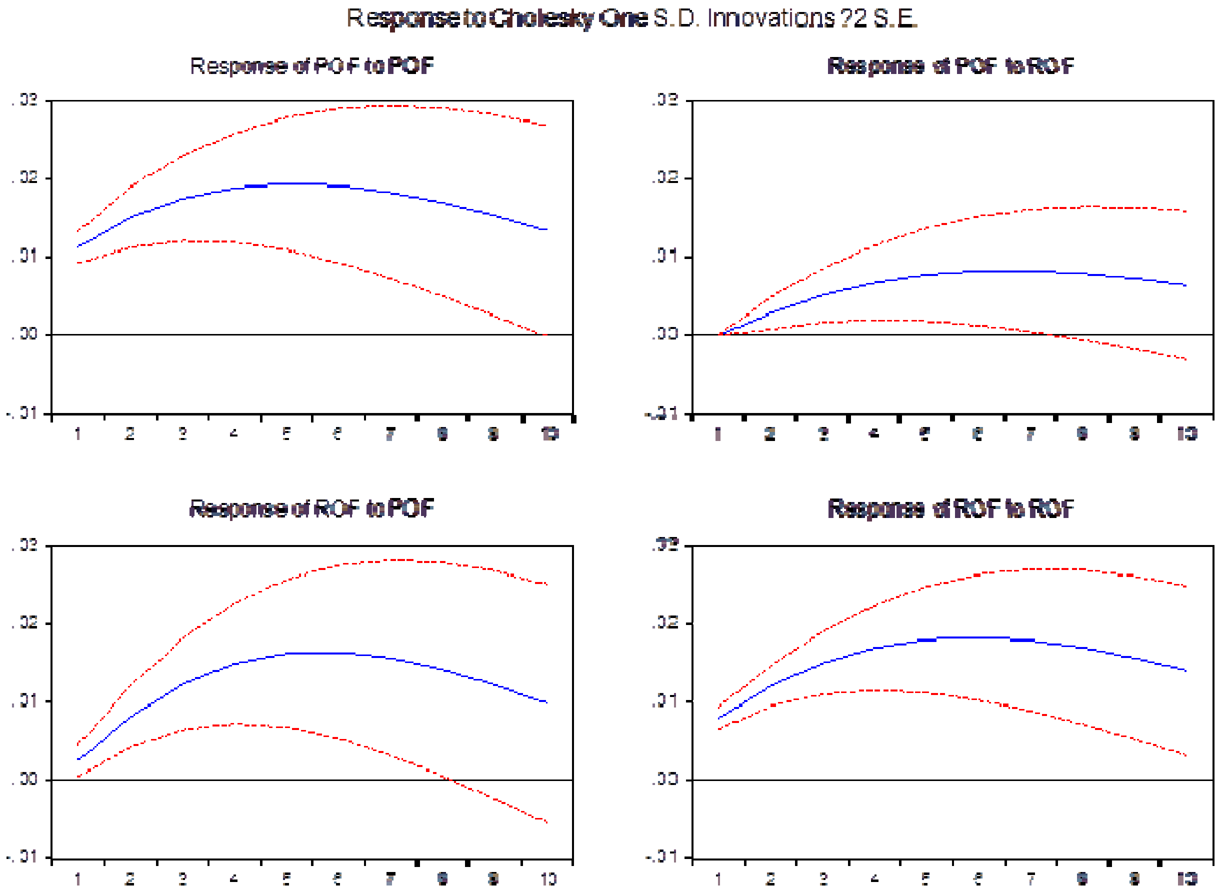

Figure 4k: Impulse responses for shop central (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

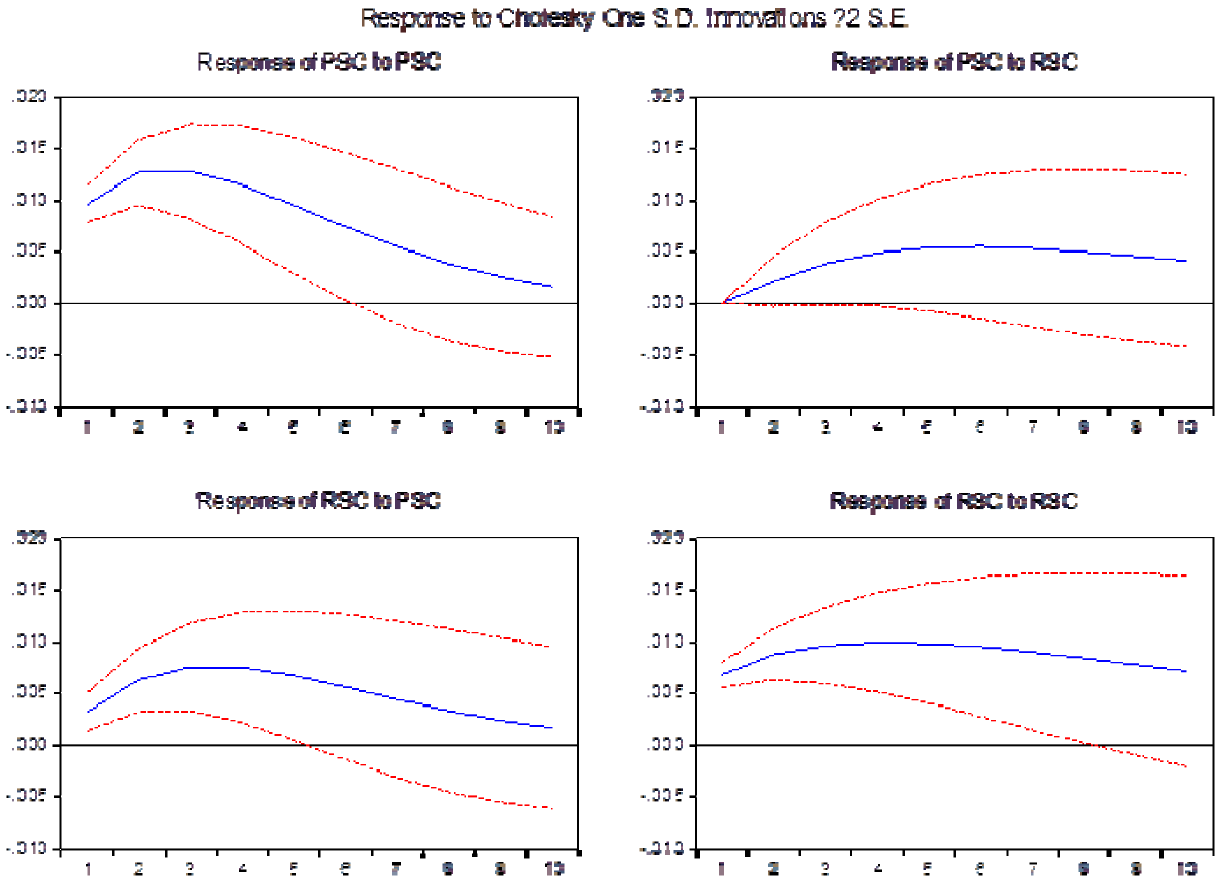

Figure 4l: Impulse responses for shop fringe (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

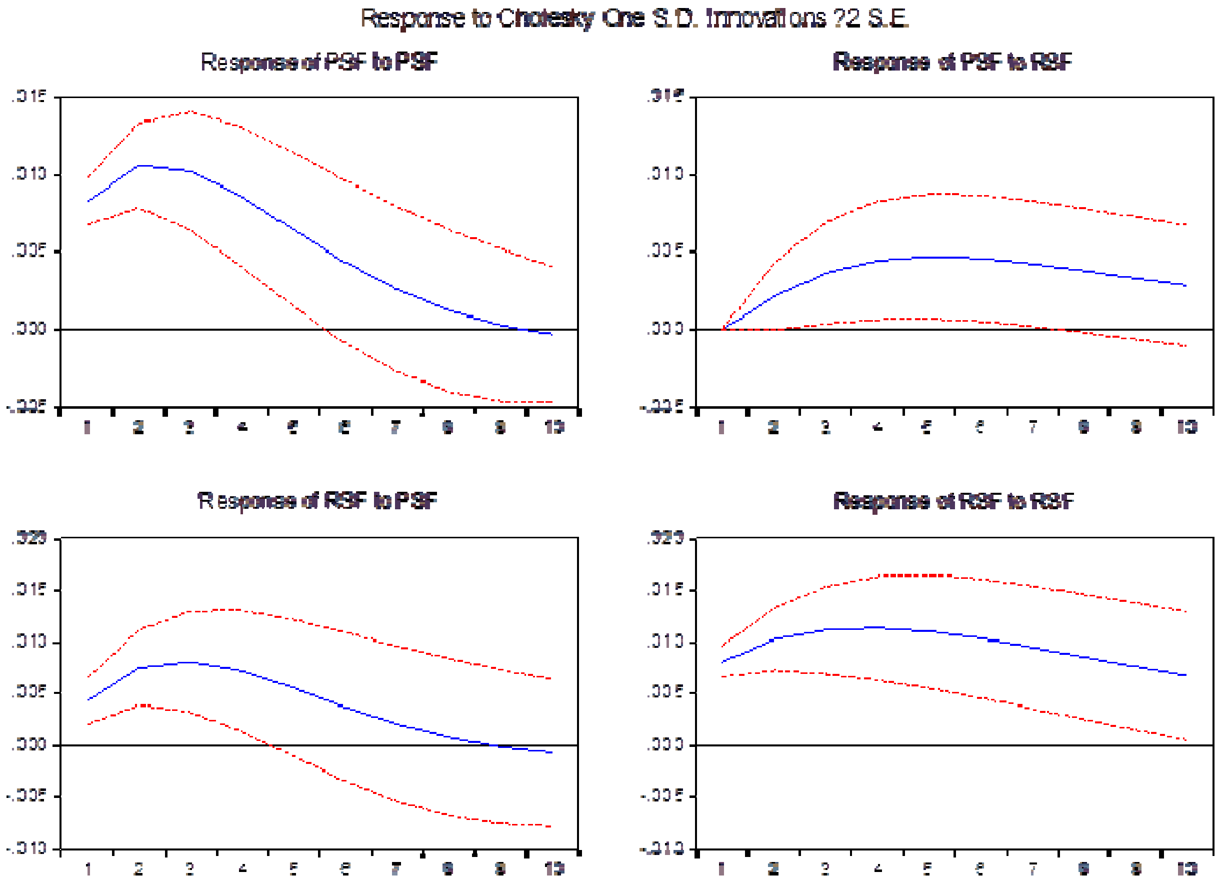

Figure 4m: Impulse responses for factory (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)

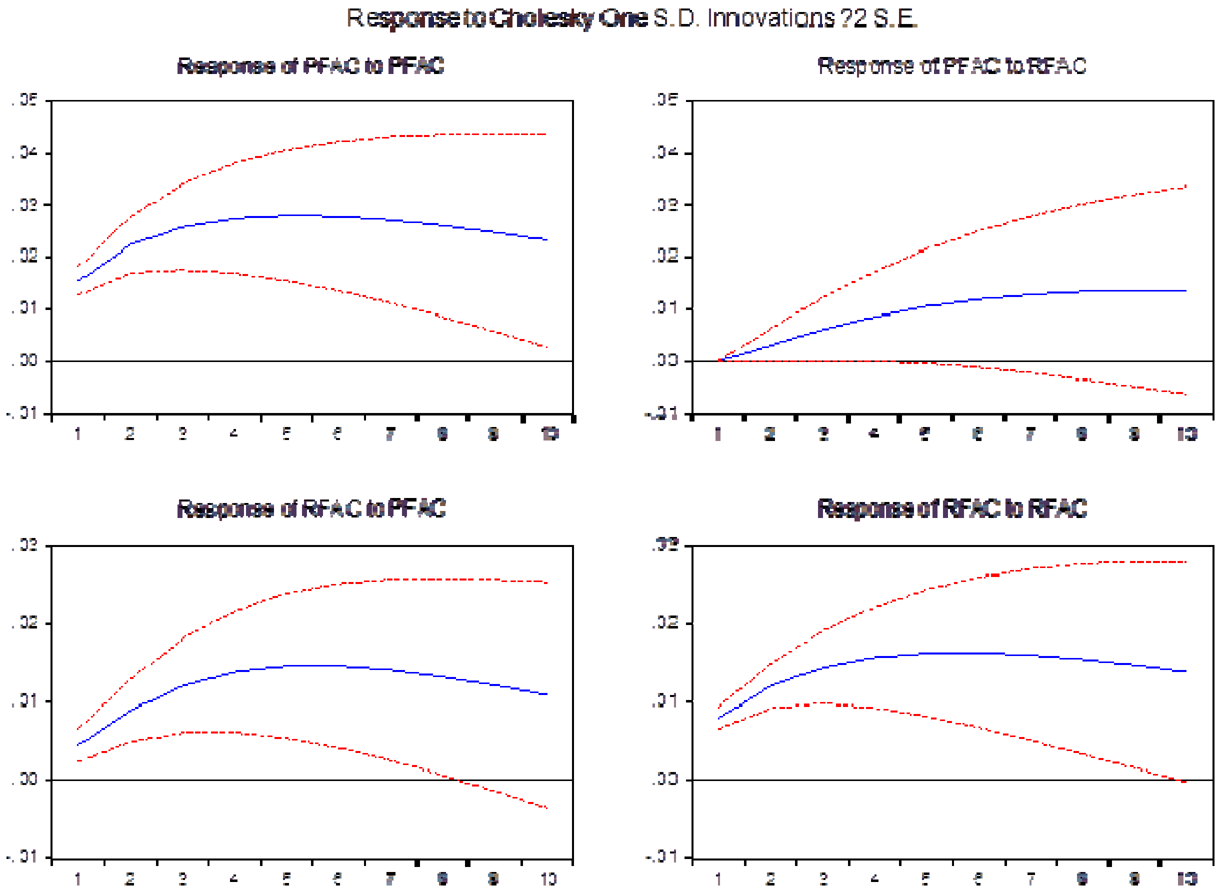

Figure 4n: Impulse responses for warehouse (Note: The solid line is the point estimate of the impulse response function. The dotted line is the 95% confidence interval)