A Study of Retail Rents with VAR Model (in South Korea)

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Abstract

This paper uses a time series analysis and a shock-response analysis of the vector auto-regression (VAR) model to find the trends in retail rents. The data of retail rent series in South Korea were compiled by three institutions (the Bank of Korea - BOK, the Kookmin Bank, and the Korea Statistic Office) from January 1995 to February 2008. The long-term trends in retail rents showed that they continued to rise in general but there was a short sluggish period. The retail rents had a positive relation with office rents, property management expenses, consumer price index, and housing deposit-basis lease value (chonsei), but negative relation with interest rate.

Keywords: retail rents, time series analysis, VAR model,

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1. Introduction

In Korea, real estate markets have been linked with financial markets in a great degree, and real estate market structure was changed after 1997 the Asian Financial Crisis. That is, general recognition on real estate is changed from financial profits based on ownership, to income profits on usage. Recently, the Korean government adopted strong policies of sales price restriction and taxes over residential properties. So investors are focusing on commercial property markets such as offices or retail buildings, as the government imposed weaker restriction on commercial properties than residential ones.

Commercial property values depend on rental values. So, it is very useful to predict commercial building rental values through logic models. Especially, it is essential for real estate investors to have information on the tendency of commercial rental values and on the risks control in the near future. So, investors can use the practical information and knowledge to grasp the characters of business cycles and to construct real estate portfolio to cope with the cycles.

This paper aims to analyse and predict retail property business conditions by utilising Korean retail rent index, and to analyse co-dependence between retail property rental values and retail property values. This paper consists of the following sections; (1) introduction, (2) literature review, (3) research methodology, (4) data and empirical results, and (5) conclusions.

2. Literature review

There were fewer empirical analyses on determination and prediction of retail rents than those on residential rents. The studies on retail property lease value are normally classified into microscopic (cross-sectional) analysis and macroscopic (time series) analysis.

The results in the research by using the cross-section analysis showed that the retail rents were affected by the terms of lease, the ratio rents, and tenant position as a national chain. In addition, it was found that gross floor area, age of shopping centre, and anchor tenant were major factors in determination of retail rents (Benjamin *et. al,* 1990). The retail rents were positively related to market area, traffic volume and were negatively related to location variables, age, and vacancy of shopping centre (Sirmans and Guidry; 1993). The condition and profitability of retail business decided the demand of retail space and it could induce the fluctuation of retail rents. The variables which were proxy to the demand strength of retail space proportionally were related to the fluctuation of retail rents.

More recent study found that the retail rents were negatively related to the distance from busstop or subway station (Hickling Lewis Brod Inc; 2002). Also, the retail rents were positively related to vacancy rate, age, the distance from shopping centre, buying power, and remodeling of shopping centre variables (Hardin, Wolverton & Carr; 2002).

There were some studies on the relation between macroeconomic variables and retail rental values (RICS, 1984; Hetherington, 1988; Clark & Dannis, 1992; McGough & Tsolacos, 1995; Tsolacos, 1995; Brooks & Tsolacos, 2000).

Clark and Dannis (1992) showed a close correlation between construction costs and general inflationary trends at the national and local levels. Rental rates would remain in a depressed state or simply increase at a rate commensurate with inflationary expectations in markets that contain sufficient growth to correct oversupply problems. The study of RICS (1984) estimated national and regional models of retail rents and demonstrated the importance of consumer spending, interest rates and new retail orders. McGough and Tsolacos (1995) suggest that the movements of retail rents convey information about their current and future values. Tsolacos (1995) suggested that a dynamic specification based on changes in gross domestic product (GDP), consumer expenditure and past movements in retail rents to estimate the British retail market performance. The studies (Hetherington; 1988, Brooks & Tsolacos; 2000) showed that GNP, retail sales, consumer price index, interest rate, construction permission quantity of commercial buildings, and vacancy rate influenced upon retail rents.

Lessors and lessees in the property market generally check a variety of the price, index, and rate related to the rental values such as the real estate rental value index, the price of commercial property, loan interest rate, consumer price index, depreciation allowance of buildings, repair expenses, and regional vacancy rate. The previous studies in USA, UK, and Australia showed that macroeconomic variables influenced upon commercial rental values.

3. Research Methodology

This paper uses a time series analysis and a shock-response analysis of the VAR (vector auto-regression) model to find the trends in monthly rents of retail properties (hereafter monthly rents). This paper aims to find the correlation between monthly rents and the macroeconomic variables in South Korea. The time series analysis is a research tool designed to investigate if there are any consistent rules that help to predict a relatively accurate value of a particular economic issue over a certain period of time. Researchers predict the future values based on the assumption that the rules would work in the same way it did in the past.

This analysis method has five assumptions: (1) the confirmed process follows the rules of a linear model. (2) No correlation is found between an explanatory variable and a probability error in other time period. (3) Probability errors do not have correlations each other all the time period, and error terms are independent. (4) Variance of time series data is same all over the period. (5) Error term mean is 0, and has a certain level of variance but it has its own normal distribution, which is called a white error. White errors refer to today's shock which is not associated with that of tomorrow. The above mentioned assumptions are widely held among researchers performing a time series analysis and a movement analysis.

The projected quantity of OLS (ordinary least squares) drawn from the first, second and third assumptions, which are needed for a time series analysis, are unbiased projection. Meanwhile, the OLS quantity earned from the first, second, third, fourth and fifth is considered the most desirable value. Particularly, the fifth assumption includes the second, third and fourth ones. The OLS quantity projection can be made by using *t*- value and *F*- value. The VAR model is used to predict the time series process through n-number liner regression equations by assuming that current value is a dependent one and the projected value is an explanatory variable. Therefore, the VAR model is a statistical time series model, which excludes prior subjectivity as much as possible and works on a generalised model based on correlation among variables.

A VAR model is a method drawn from a structural quantity model which was not defined previously and also obtained from coefficient variables predicted through the VAR. Therefore correlation among variables inside the model is more important than coefficients drawn from the VAR model.

4. Empirical Results

4.1 Data

This study used the main data which were surveyed and complied by three institutions (the Bank of Korea, the Kookmin Bank, and the Korea Statistic Office) from January 1995 to February 2008. The source of data-set was composed of economic indicators as shown in the Table 1.

< Table 1 > Table of Statistical Variables

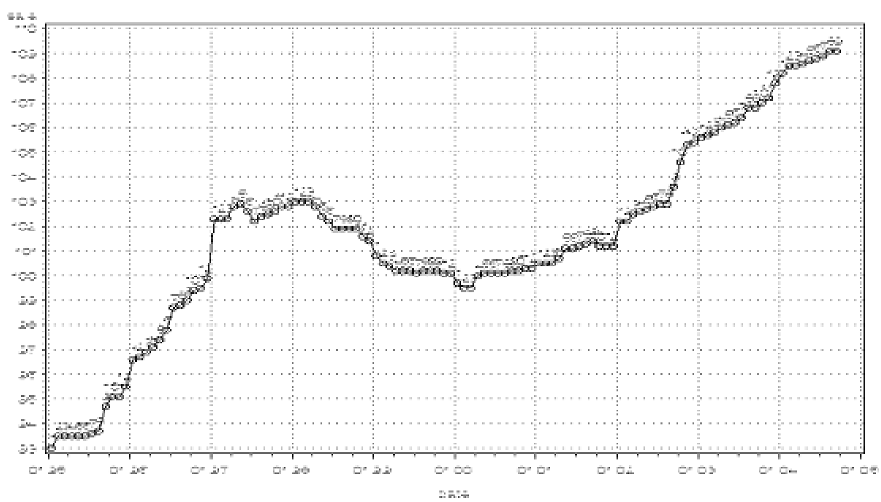
Variables	Economic Indicators	Sign	Data Source
Retail rent	Retail rent index	RR	The Bank of Korea
Office rent	Office rent index	OR	The Bank of Korea
Real estate outgoings	Real estate Outgoings index	OU	The Bank of Korea
Interest rate	Yield on corporate bonds with a three-year	IR	The Bank of Korea
House rental price	House rental value index (House *chonsei* index)	HC	The Kookmin Bank
Consumer price	Consumer price index	CP	The Korea Statistic Office

4.2 Time Series Analysis of Monthly Rents of Retail Properties

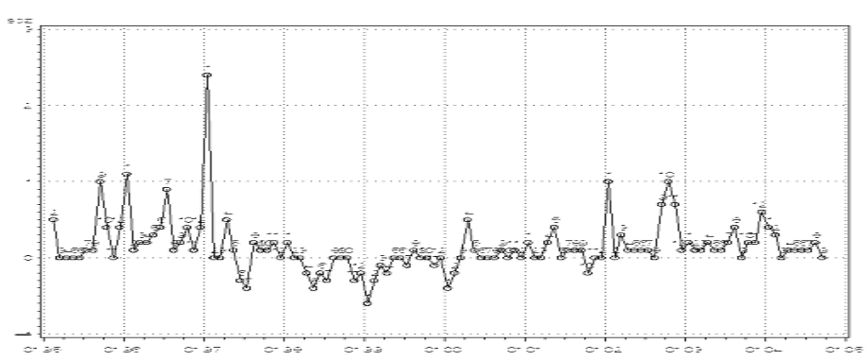
In the Figure 1, the trends of monthly retail rents in major cities and provinces showed that the monthly rents had risen from 1995 to 1997, and had fallen from 1998 until 2000. Then, they had slowly risen between 2000 and 2003 and continued to rise since.

The data between January 1995 and September 2005 were used to establish the model and the projected values of the fourth quarter of 2004 and the first quarter of 2005 based on the model were compared with the actual data. The trends in monthly rents and ACF/PACF (Appendix 1 & 2) found that there were changes in an average value during the time period and the changes were analysed in this study. There were no major differences in variance of monthly rents by month. However, there were some periods showing a drastic change. But, after power transformation in that period, there was no major difference between actual data and normality of data. So the actual data were used in this study.

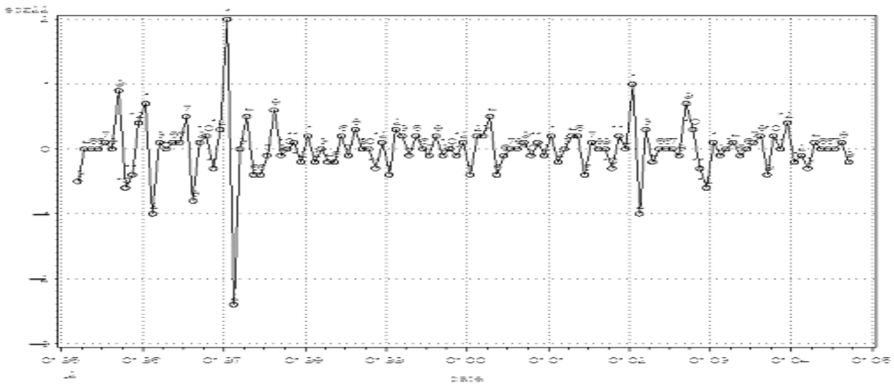
<Figure 1 > Trends in Monthly Rents



<Figure 2> Trends after First Order Difference



<Figure 3> Trends after Second Order Difference



According to the results after data transformation for the projection of monthly retail rents, the trend with second order difference was closer to a normal trend than first order difference. The results of second order difference were used for the ARMA model. The means and variances of given series have abnormal distribution as the means and variances go up. Particularly, the variances are increasing as increased aggregated results. As the Figure 2 shows, the means of the trends after applying a first order difference are consistent, which is close to 0, but the variances go up in the beginning and then decreases as time passes. The Figure 3 explains the trends after second order difference show a feasible value, showing no decreasing trends afterwards and the series having a normal distribution. The trends after second order difference satisfied a normal mean, reassuring monthly rents were identical abnormal. To support the finding, the given autocorrelation function was analysed.

The first step was that one model should be distinguished from another and the presumed autocorrelation function and the partial autocorrelation function were compared with two theoretical correlation functions to identify whether they were identical or not. This was an important step to set a univariate ARIMA model. The projected ACF (Appendix 3) showed a censored form having autocorrelation in series 1 and 5. The PACF (Appendix 4) had partial autocorrelation in the series 1, 2, 3, 5, 7 and 11. So the seven models of ARMA(1,1), ARMA(1,5), ARMA(2,1), ARMA(2,5), ARMA(3,1), ARMA(3,5), and ARMA (5,1) models were selected to compare and choose an ideal model. A Conditional Least Squares (CLS) method was used to predict the results. The CLS method is a tool that controls few values obtained in the beginning and minimizes the residual sum of squares after fixing a few residuals to 0 in an effort to predict a parameter.

The second step was to predict an appropriate model explaining the trends in monthly rents. The test results of ARMA (5,1) found no significant results in μ and $Z_{t-1} \sim Z_{t-4}$ variables as shown in the Table 2.

<Table 2> First Order ARMA (5,1) First Order

Conditional Least Squares Estimation

Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|	Lag
MU	-0.0018452	0.0051855	-0.36	0.7227	0
MA1,1	0.78050	0.11279	6.92	<.0001	1
AR1,1	0.04684	0.13647	0.34	0.7321	1
AR1,2	-0.15365	0.11709	-1.31	0.1922	2
AR1,3	-0.02575	0.11824	-0.22	0.8280	3
AR1,4	-0.03644	0.10570	-0.34	0.7310	4
AR1,5	-0.22516	0.10403	-2.16	0.0326	5

Constant Estimate	-0.00257
Variance Estimate	0.117094
Std Error Estimate	0.34219
AIC	86.48421
SBC	105.6987
Number of Residuals	115

* AIC and SBC do not include log determinant.

<Table 3> Modified ARMA (5,1)

Conditional Least Squares Estimation

Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|	Lag
MA1,1	0.81728	0.05547	14.73	<.0001	1
AR1,1	-0.21101	0.09401	-2.24	0.0267	5

Variance Estimate	0.114787
Std Error Estimate	0.338803
AIC	79.40081
SBC	84.89067
Number of Residuals	115

* AIC and SBC do not include log determinant.

In the Table 3, another test without the insignificant variables shows all significant results. (AIC is 79.40081, and SBC is 84.89067.) ARMA (5,1) shows the lowest values for AIC (79.40081) and SBC (84.89067). Then, this model was selected as an ideal one, which is shown as the Equation 4.1.

$$(1+0.21101B^{5})\ {}^{2}Z_t=(1-0.81728B)a_t \quad (4.1)$$

The third step was to assess prediction models for retail rents. The P-values of ARMA (5,1) residuals ACF, PACF, and Portmanteau Q test results (Appendixes 5, 6, & 7) were larger than 0.05 and the absolute autocorrelation value was smaller than 2/√n=0.185. It showed that this model was an ideal one.

<Table 4> Predicted Value

Forecasts for variable retail rent

Obs	Forecast	Std Error	95% Confidence Limits	
118	109.2627	0.3388	108.5987	109.9268
119	109.4255	0.5247	108.3970	110.4539
120	109.5882	0.6995	108.2171	110.9593
121	109.7298	0.8744	108.0161	111.4435
122	109.9136	1.0528	107.8502	111.9771
123	110.0631	1.2005	107.7102	112.4160

The last step was the model prediction results. The observed value of October 2004 was 109.2 (obs = 118) and the observed value of November 2004 was 109.4 (obs = 119). Based on the predicted values of the fourth quarter 2004 and the first quarter of 2005, the predicted values of retail rents were shown in the Table 4. The predicted value of October 2004 was 109.2627 (obs = 118) and the predicted value of November 2004 was 109.4255 (obs = 119), which were very close to the actual values of 109.2 and 109.4. The trends in Z_t and Hat(Z_t) were also close to predicted results.

4.3 Monthly Rents of Retail Property and Macroeconomic Variables

The time series data of the main variables shows a high level of correlation among all variables as shown in the Table 5, Correlation Matrix (1). There is also a high level of correlation between the changes of monthly rents of retail properties and the changes of office rents, which was identified in the Table 5, Correlation Matrix (2).

All variables showed highly stable degree of times series (Appendix 10). The interest rates were sensitive to the external risks such as the Asian Financial Crisis, while the monthly rents of retail properties were relatively slow to those external variables. Since 2000, the interest rates continued to fall down, but, to the contrary, the monthly rents rose up. This supported that there was a negative correlation between the monthly rents and the interest rates.

<Table 5> Correlation Analysis of Main Variables

Correlation Matrix(1)

	LOG_RR	LOG_OR	LOG_HC	LOG_OU	LOG_IR	LOG_CP
LOG_RR	1	0.99**	0.79**	0.95**	-0.74**	0.93**
LOG_OR	0.99**	1	0.80**	0.95**	-0.74**	0.92**
LOG_HC	0.79**	0.79**	1	0.82**	-0.83**	0.84**
LOG_OU	0.95**	0.95**	0.82**	1	-0.83**	0.99**
LOG_IR	-0.74**	-0.74**	-0.83**	-0.83**	1	-0.86**
LOG_CP	0.93**	0.93**	0.84**	0.99**	0.86**	1

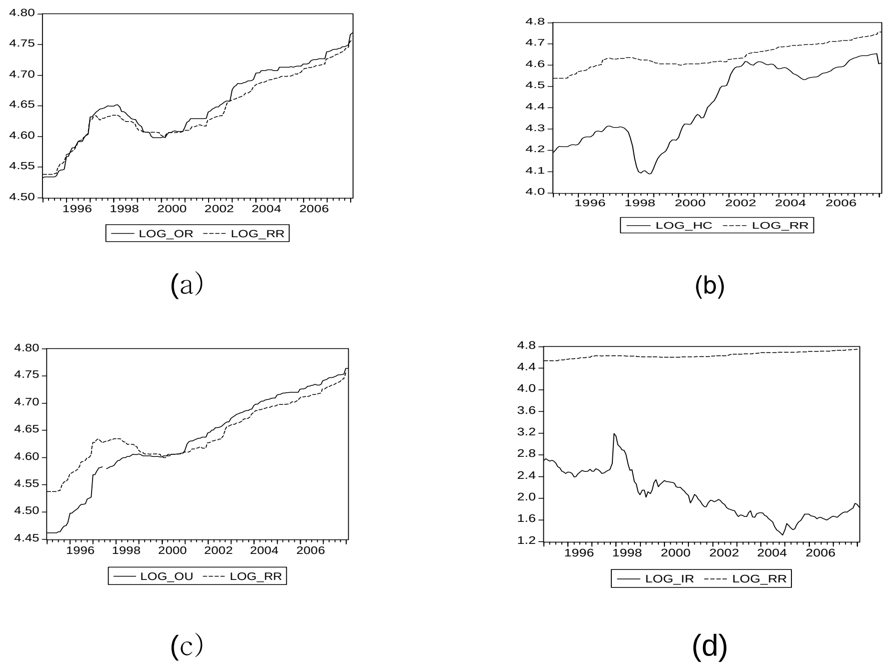
Correlation Matrix(2)

	RR_V	OR_V	HC_V	OU_V	IR_V	CP_V
RR_V	1	0.72**	-0.30	-0.102	0.102	0.15
OR_V	0.72**	1	-0.17	-0.006	-0.010	0.20
HC_V	-0.03	-0.17	1	0.004	0.067	0.079
OU_V	-0.012	0.006	0.004	1	0.002	0.066
IR_V	0.102	-0.010	0.067	0.002	1	0.17*
CP_V	0.15	0.20*	0.079	0.06	0.17*	1

** Note: RR_V (change rate in retail rent); OR_V (change rate in office rent); HC_V (change rate in house *chonsei* rent); IR_V (change rate in yield on corporate bonds with a three-year); OU_V (change rate in outgoings); CP_V (change rate in CPI)

The Figure 4 shows that the trends in office rents, which were part of commercial properties, had similar trend to retail properties. Since 2001, the office rents had gone up more than monthly rents of retail properties. The trends in the housing rents continued to rise up, except the drastic fluctuations twice over the time period because of the impact of the Asian Financial Crisis and the government's interruption on the housing market. Since the crisis, there was a relatively brief sluggish period until 1998, but the housing rents rose again. The trends of monthly rents of retail properties were in line with the office rents as well as costs requiring for managing properties. The housing rents tended to have a positive correlation with monthly rents of retail properties, and the housing rents were more affected by the external shocks than the retail rents. There was a negative correlation between monthly rents of retail properties and the interest rates.

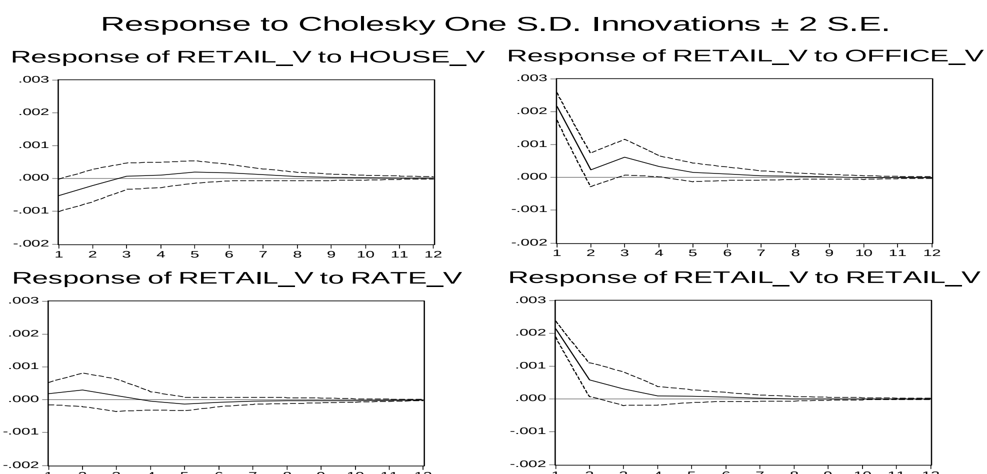
<Figure 4> Correlation between Main Variables



** Note. LOG_RR (change rate in retail rent); LOG_OR (change rate in office rent); LOG_HC (change rate in house *chonsei* rent); LOG_IR (change rate in yield on corporate bonds with a three-year); LOG_OU (change rate in outgoings)

In the Figure 5, it shows that an increase of 0.022 of monthly rents of retail properties occur next month when shock was equal to one standard variance. The level of an increase of next month rents was 0.01. This implies that current shock would give significant or positive effect on an increase of monthly rents of retail properties that would last about 10 months. It also supports that current shocks gives permanent either positive or negative effect on monthly rents.

<Figure 5> Shock-Response Function



4.4 Regression Model for Changes Rate of Retail Rents

In the Table 6, the constant for the regression equation was 0.058, and the regression coefficient for the LOG_OR(t) was 51.884. Also, t-value of the LOG_OR(t) was 10.818, and the probability of significance was 0.5%, thereby rejecting H_0 from the hypotheses $H_0\,\beta=0$, $H_1\,\beta=0$, and α=0.05. This means that LOG_OR(t) was the variable that affected the retail rents the most. In addition, the t-value of the LOG_OU(t-9) was 2.179, the significance probability was 0.05, so H_0 was rejected with α=0.05. Moreover, with α=0.05 it was statistically significant for the regression coefficient of each variable representing LOG_OR(t-2) (t-value: 1.835, significance probability: 0.068), LOG_HC(t-10) (t-value: -0.154, significance probability: 0.878), LOG_OU(t-9) (t-value: 2.179, significance probability: 0.983), LOG_CPI(t-14) (t-value: -1.104, significance probability: 0.670),and LOG_CPI(t-15) (t-value: -0.007, significance probability: 0.995).

<Table 6> Regression Model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.058	.026		2.268	.025		
	l_or(t)	51.884	4.796	.665	10.818	.000	.796	1.256
	l_or(t-2)	8.235	4.487	.106	1.835	.068	.909	1.100
	l_hc(t-10)	-.296	1.923	-.010	-.154	.878	.677	1.477
	l_ou(t)	-.102	4.799	-.001	-.021	.983	.795	1.257
	l_ou(t-9)	10.093	4.633	.124	2.179	.031	.934	1.070
	l_cpi(t-14)	-4.999	4.528	-.074	-1.104	.271	.670	1.493
	l_cpi(t-15)	-.028	4.063	.000	-.007	.995	.830	1.205

a. Dependent Variable: l_rr(t)

** Note. l_rr (change rate in retail rent); l_or (change rate in office rent);l_hc (change rate in house *chonsei* rent); l_ir (change rate in yield on corporate bonds with a three-year); l_ou (change rate in outgoings); l _cpi (change rate in CPI)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.738(a)	.545	.524	.224	1.552

a Predictors: (Constant), l_cpi(t-15), l_ou(t), l_ou(t-9), l_or(t-2), l_or(t), l_hc(t-10), l_cpi(t-14)

b Dependent Variable: l_rr(t)

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.127	7	1.304	25.874	.000[a]
	Residual	7.609	151	.050		
	Total	16.736	158			

a. Predictors: (Constant), l_cpi(t-15), l_ou(t), l_ou(t-9), l_or(t-2), l_or(t), l_hc(t-10), l_cpi(t-14)

b. Dependent Variable: l_rr(t)

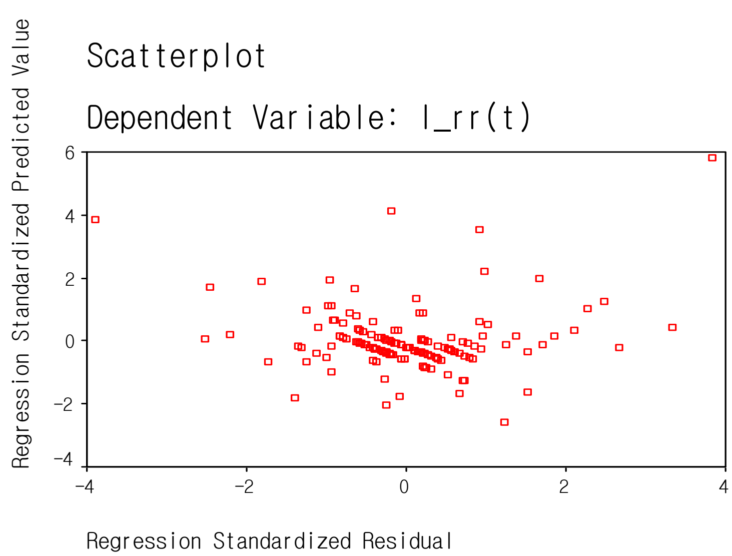
The Table 6, based on the parameter estimate of regression coefficient, indicates the regression equation (4.2).

$$\hat{y} = 0.058+51.88 * \text{'l\_or'}(t) + 10.093* \text{'l\_ou'}(t\text{-}9). \quad (4.2)$$

Next, this study investigated the relative importance of variables in explaining retail rents. When the standardized regression coefficient (Beta) was used to find out the weight of each explanatory variable, the importance decreased among the variables according to the following order; the LOG_OR(t) (10.818), LOG_OU(t-9) (2.179).

A regression analysis was performed to verify the appropriateness of the final model in equation. The regression analysis includes residual analysis, influence evaluation, and multi-collinearity. This study was verified by mainly residual analysis while influence evaluation and multi-collinearity were used to aid the main analysis.

< Figure 6> Residual Plot



The value of Durbin-Watson was obtained to discover the independent nature of residue. As the value is 1.552, the independent nature of residue is also satisfied. In order to check the homogeneity of variable in residue, a residual plot was drawn in the Figure 6.

5. Conclusion

This paper investigated the relationship between the macroeconomic variables and retail rents in South Korea. The results of the study can be summarized as below:

(1) The average rents of retail properties in Korea was generally on the tendency of increase and fluctuations of retail rents got stable after the Asian financial crisis.
(2) ARMA(5,1), one of the time-series analysis model, was more suitable to predict the retail rents than any other type of models.
(3) The retail rents had an affirmative relation with office rents, property management expenses, consumer price index, and housing deposit-basis lease value (*chonsei*), but negative relation with interest rate.
(4) This study formulated a model predicting retail rents at the time point of t with multiple regression analysis. Office rents at the time point of t and property management expenses at the time of t-9 were significant statistically in the explanation valuables.

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< Appendix 1> AFC of Retail Rent Index

```
                                   Autocorrelations

Lag    Covariance    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1      Std Error

  0     14.756372        1.00000    |                    |********************|             0
  1     14.129363        0.95751    |                  . |******************* |      0.092450
  2     13.486237        0.91393    |                .   |******************  |      0.155625
  3     12.823644        0.86902    |              .     |*****************   |      0.196207
  4     12.123965        0.82161    |             .      |****************    |      0.226730
  5     11.390023        0.77187    |            .       |***************     |      0.250890
  6     10.640706        0.72109    |           .        |**************      |      0.270426
  7      9.862243        0.66834    |           .        |*************       |      0.286389
  8      9.052147        0.61344    |          .         |************        |      0.299423
  9      8.295062        0.56213    |          .         |***********.        |      0.309979
 10      7.549429        0.51160    |         .          |**********  .       |      0.318572
 11      6.800520        0.46085    |         .          |*********   .       |      0.325519
 12      6.069626        0.41132    |         .          |********    .       |      0.331048
 13      5.390186        0.36528    |         .          |*******     .       |      0.335388
 14      4.691505        0.31793    |        .           |******       .      |      0.338771
 15      4.016689        0.27220    |        .           |*****        .      |      0.341312
 16      3.347001        0.22682    |        .           |*****        .      |      0.343162
 17      2.677636        0.18146    |        .           |****         .      |      0.344441
 18      2.035337        0.13793    |        .           |***          .      |      0.345257
 19      1.467330        0.09944    |        .           |**           .      |      0.345728
 20      0.897785        0.06084    |        .           |*            .      |      0.345972
 21      0.339000        0.02297    |        .           |             .      |      0.346064
 22     -0.184933        -.01253    |        .           |             .      |      0.346077
 23     -0.690490        -.04679    |        .          *|             .      |      0.346081
 24     -1.131744        -.07670    |        .         **|             .      |      0.346135

                                              "." marks two standard errors
```

< Appendix 2> PAFC of Retail Rent Index

```
                         Partial Autocorrelations

  Lag   Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

    1      0.95751    |                    .  |******************* |
    2     -0.03484    |                   . *|  .                  |
    3     -0.03849    |                   . *|  .                  |
    4     -0.05395    |                   . *|  .                  |
    5     -0.05325    |                   . *|  .                  |
    6     -0.03943    |                   . *|  .                  |
    7     -0.05185    |                   . *|  .                  |
    8     -0.05578    |                   . *|  .                  |
    9      0.01167    |                   .  |  .                  |
   10     -0.02175    |                   .  |  .                  |
   11     -0.03471    |                   . *|  .                  |
   12     -0.02052    |                   .  |  .                  |
   13      0.00578    |                   .  |  .                  |
   14     -0.05086    |                   . *|  .                  |
   15     -0.01897    |                   .  |  .                  |
   16     -0.03704    |                   . *|  .                  |
   17     -0.03748    |                   . *|  .                  |
   18     -0.01691    |                   .  |  .                  |
   19      0.01978    |                   .  |  .                  |
   20     -0.03945    |                   . *|  .                  |
   21     -0.02716    |                   . *|  .                  |
   22     -0.01486    |                   .  |  .                  |
   23     -0.02535    |                   . *|  .                  |
   24      0.01344    |                   .  |  .                  |
```

<Appendix 3> SIACF of Time Series that used Difference

```
                                   Autocorrelations

Lag   Covariance   Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1   Std Error

  0     0.182155       1.00000   |                    |********************|           0
  1    -0.069732       -.38282   |            ********|   .                |    0.093250
  2    -0.031562       -.17327   |                .***|   .                |    0.106039
  3     0.014177       0.07783   |                .   |** .               |    0.108473
  4     0.016351       0.08976   |                .   |** .               |    0.108958
  5    -0.041044       -.22533   |               *****|   .                |    0.109599
  6     0.025473       0.13985   |                .   |*** .              |    0.113556
  7   -0.0082015       -.04502   |               .   *|    .               |    0.115044
  8   -0.0018274       -.01003   |               .    |    .               |    0.115197
  9    0.0076734       0.04213   |               .    |*   .               |    0.115204
 10     0.015556       0.08540   |               .    |**  .               |    0.115338
 11    -0.039340       -.21597   |               .****|    .               |    0.115887
 12     0.037125       0.20381   |               .    |****.               |    0.119335
 13   -0.0055598       -.03052   |               .   *|    .               |    0.122325
 14    -0.015828       -.08690   |               .  **|    .               |    0.122391
 15   -0.0002709       -.00149   |               .    |    .               |    0.122926
 16     0.025030       0.13741   |               .    |*** .               |    0.122926
 17    -0.017508       -.09611   |               .  **|    .               |    0.124255
 18    -0.012525       -.06876   |               .   *|    .               |    0.124899
 19     0.016167       0.08875   |               .    |**  .               |    0.125228
 20   -0.0028804       -.01581   |               .    |    .               |    0.125774
 21     0.010170       0.05583   |               .    |*   .               |    0.125791
 22    -0.028427       -.15606   |               . ***|    .               |    0.126007
 23     0.032552       0.17870   |               .    |****.               |    0.127676
 24    -0.025021       -.13736   |               . ***|    .               |    0.129833

                            "." marks two standard errors
```

<Appendix 4> PACF of Time Series that used Difference

```
                         Partial Autocorrelations

 Lag    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

   1       -0.38282    |        ********|    .                  |
   2       -0.37473    |         *******|    .                  |
   3       -0.21375    |            ****|    .                  |
   4       -0.04184    |              . *|    .                  |
   5       -0.26906    |           *****|    .                  |
   6       -0.09208    |             . **|    .                  |
   7       -0.18966    |            ****|    .                  |
   8       -0.15794    |             .***|    .                  |
   9       -0.08427    |             . **|    .                  |
  10        0.01929    |              .  |    .                  |
  11       -0.18982    |            ****|    .                  |
  12        0.04272    |              .  |*   .                  |
  13        0.00668    |              .  |    .                  |
  14       -0.02496    |              .  |    .                  |
  15       -0.01807    |              .  |    .                  |
  16        0.05639    |              .  |*   .                  |
  17        0.09072    |              .  |** .                   |
  18       -0.05416    |              . *|    .                  |
  19        0.01673    |              .  |    .                  |
  20       -0.02520    |              . *|    .                  |
  21        0.15715    |              .  |***.                   |
  22       -0.17009    |             .***|    .                  |
  23        0.15691    |              .  |***.                   |
  24       -0.13294    |             .***|    .                  |
```

<Appendix 5> Portmanteau Q Test of Autocorrelation

Autocorrelation Plot of Residuals

```
Lag   Covariance    Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1    Std Error
 0    0.114787       1.00000      |                    |********************|    0
 1    0.0093107      0.08111      |                 .  |** .                 |    0.093250
 2    -0.015762      -.13732      |                .***|    .                |    0.093862
 3    -0.0020642     -.01798      |                 .  |    .                |    0.095593
 4    0.0019247      0.01677      |                 .  |    .                |    0.095622
 5    0.0010760      0.00937      |                 .  |    .                |    0.095648
 6    0.0016405      0.01429      |                 .  |    .                |    0.095656
 7    -0.0024133     -.02102      |                 .  |    .                |    0.095674
 8    0.0030579      0.02664      |                 .  |*   .                |    0.095715
 9    0.0091306      0.07954      |                 .  |** .                 |    0.095779
10    0.0057487      0.05008      |                 .  |*   .                |    0.096352
11    -0.0076375     -.06654      |                 . *|    .                |    0.096578
12    0.016587       0.14451      |                 .  |***.                 |    0.096976
13    -0.0003315     -.00289      |                 .  |    .                |    0.098830
14    -0.0054195     -.04721      |                 . *|    .                |    0.098831
15    0.0030505      0.02657      |                 .  |*   .                |    0.099027
16    0.0085504      0.07449      |                 .  |*   .                |    0.099089
17    -0.010725      -.09343      |                . **|    .                |    0.099575
18    -0.0093720     -.08165      |                . **|    .                |    0.100334
19    0.00064118     0.00559      |                 .  |    .                |    0.100910
20    0.00023937     0.00209      |                 .  |    .                |    0.100913
21    0.0012637      0.01101      |                 .  |    .                |    0.100913
22    -0.017775      -.15485      |                .***|    .                |    0.100924
23    0.0047496      0.04138      |                 .  |*   .                |    0.102969
24    -0.0092939     -.08097      |                . **|    .                |    0.103114
```

"." marks two standard errors

<Appendix 6> PACF Partial Correlation

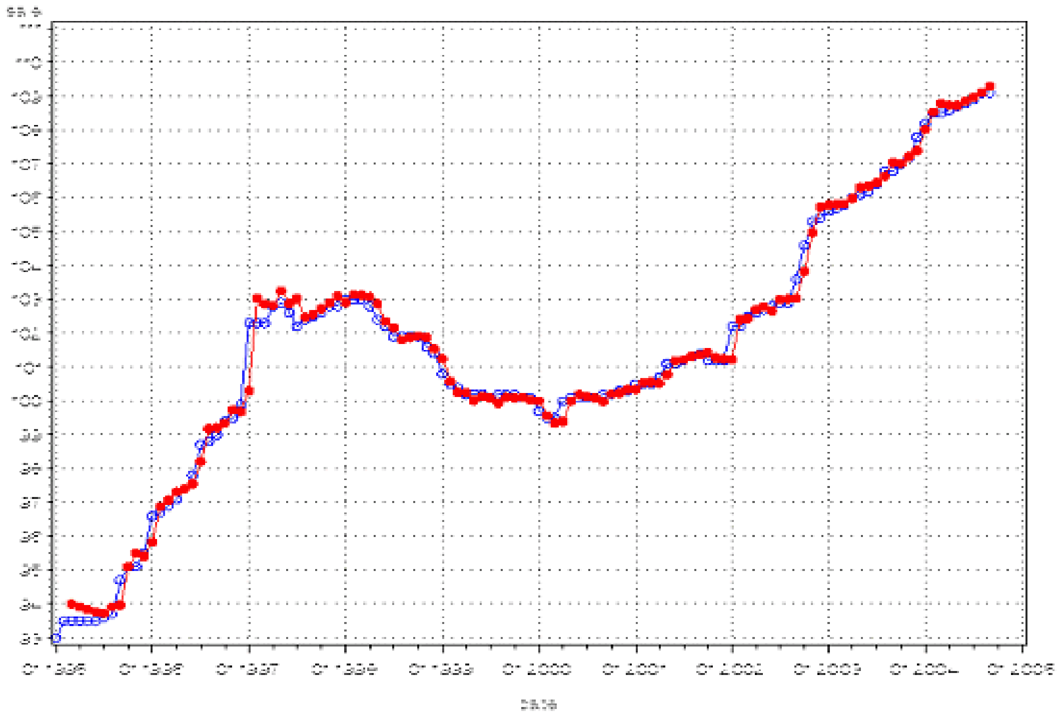
```
                    Partial Autocorrelations

 Lag    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

  1       0.08111      |                    .  |** .                    |
  2      -0.14485      |                  .***|   .                    |
  3       0.00670      |                    .  |   .                    |
  4      -0.00212      |                    .  |   .                    |
  5       0.00648      |                    .  |   .                    |
  6       0.01552      |                    .  |   .                    |
  7      -0.02233      |                    .  |   .                    |
  8       0.03591      |                    .  |*  .                    |
  9       0.06984      |                    .  |*  .                    |
 10       0.04598      |                    .  |*  .                    |
 11      -0.05567      |                    . *|   .                    |
 12       0.17582      |                    .  |****                    |
 13      -0.05416      |                    . *|   .                    |
 14       0.00014      |                    .  |   .                    |
 15       0.02764      |                    .  |*  .                    |
 16       0.06347      |                    .  |*  .                    |
 17      -0.11029      |                    . **|   .                   |
 18      -0.06009      |                    . *|   .                    |
 19      -0.00302      |                    .  |   .                    |
 20      -0.02826      |                    . *|   .                    |
 21      -0.00444      |                    .  |   .                    |
 22      -0.19438      |                  ****|   .                    |
 23       0.12984      |                    .  |***.                    |
 24      -0.21469      |                  ****|   .                    |
```

<Appendix 7> Model Prediction

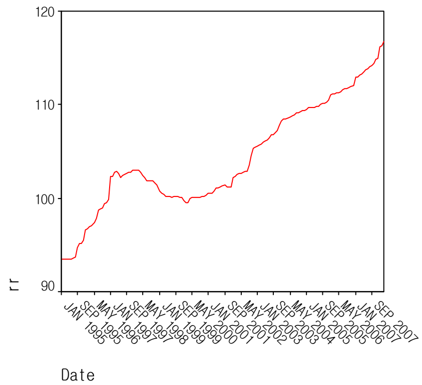
Autocorrelation Check of Residuals

To Lag	Chi-Square	DF	Pr > ChiSq	------Autocorrelations----------					
6	3.13	4	0.5362	0.081	-0.137	-0.018	0.017	0.009	0.014
12	7.70	10	0.6581	-0.021	0.027	0.080	0.050	-0.067	0.145
18	10.97	16	0.8113	-0.003	-0.047	0.027	0.074	-0.093	-0.082
24	15.68	22	0.8314	0.006	0.002	0.011	-0.155	0.041	-0.081

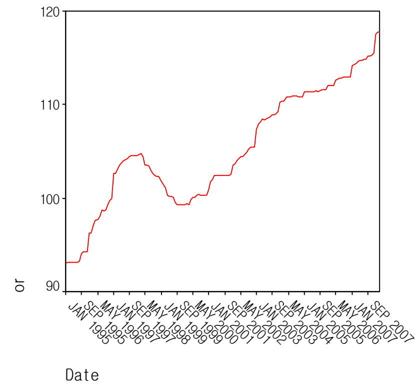
<Appendix 8> Time Series of Actual Value and Predicted Value



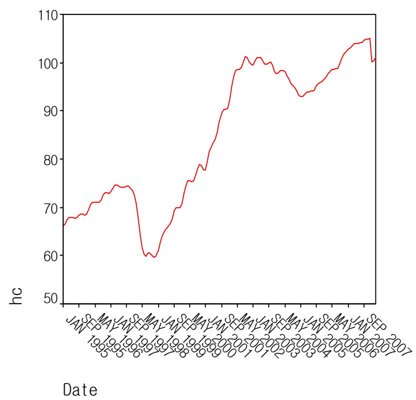
<Appendix 9> Trends in Main Variables



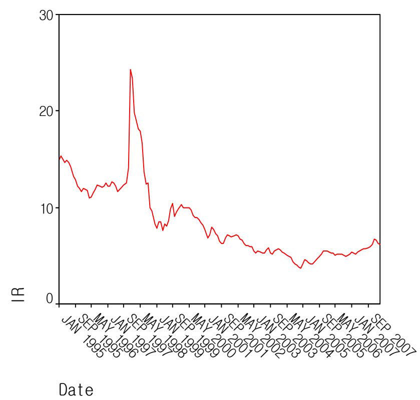
(a)



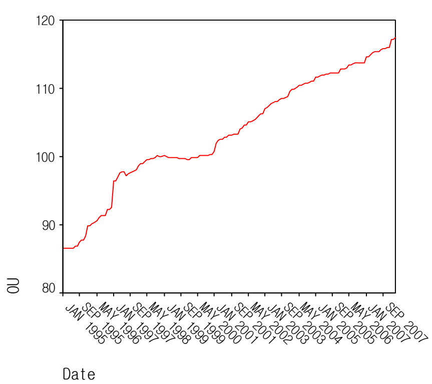
(b)



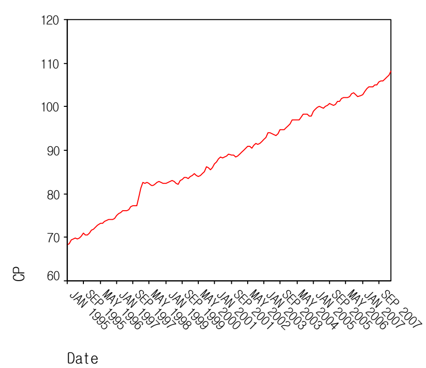
(c)



(d)



(e)

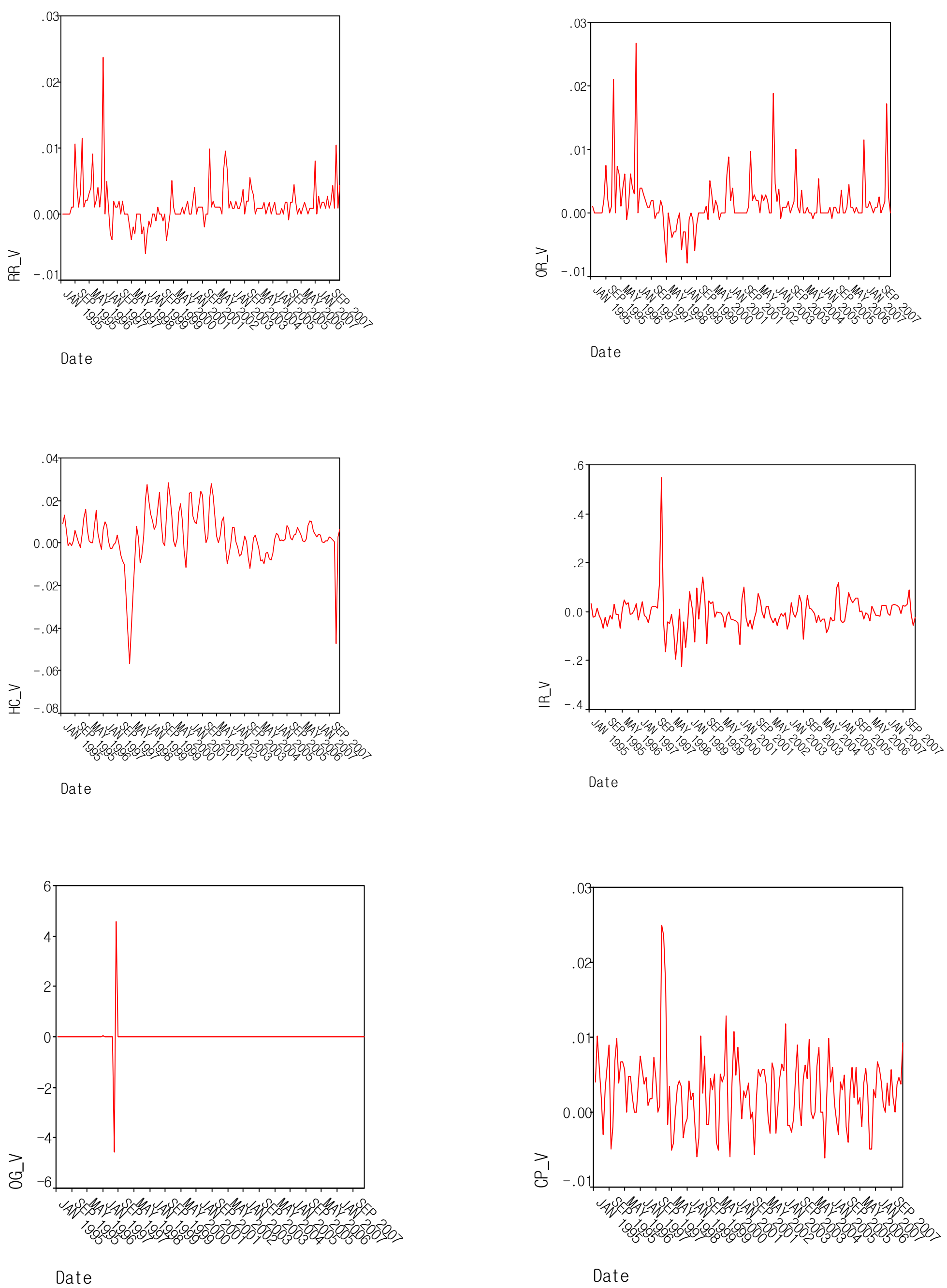


(f)

** Note: RR (retail rent); OR (office rent); HC (*chonsei* rent); IR (yield on corporate bonds with a three-year);

OU (outgoings); CP (CPI)

<Appendix 10> Trend of Change Rate in the Variables (Unit: %)



** Note: RR_V (change rate in retail rent); OR_V (change rate in office rent); HC_V (change rate in house *chonsei* rent);

IR_V (change rate in yield on corporate bonds with a three-year); OG_V (change rate in outgoings); CP_V (change rate in CPI)