Chapter 1

Introduction to RATS

The first exercise uses exchange rate data found on the file labeled EXRATES.PRN. The file contains quarterly exchange rates for the U.S. dollar against the currencies of the UK, France, Germany, Italy, Canada, and Japan over the sample period 1973:1 through 1990:4. Each observation has been normalized such that the first quarter of 1971 equals 1.00. Here are the first four instructions of the program:

```
calendar 1973 1 4
allocate 1990:4
open data r:\econ302\exrates.wk1
data(format=prn,org=obs) /
```

The CALENDAR statement instructs RATS that the data starts with the first period of 1973 and that the data is quarterly. The most commonly used syntax of the CALENDAR instruction is:

```
calendar year period frequency
```

where:
- `year` The year of the first entry in the data set
- `period` The period of the first entry in the data set
- `frequency` The number of observations per year.

**Examples:**
- For monthly data beginning with February 1973, use `calendar 1973 2 12`.
- For semiannual data beginning with July 1973, use `calendar 1973 2 2`.
- For annual data it is permissible to use only the starting year. As such, you can omit the period and frequency and use the more compact `calendar 1973` instead of `calendar 1973 1 1`.

Note that you can use only the last two digits for the year. Thus, `calendar 1973 1 4` is equivalent to `calendar 73 1 4`. (Be careful if you have data beginning in the 19th century or once we have reached the year 2000.) Since each RATS instruction can be abbreviated using only the first three letters of the instruction, WALKTOUR.PRG could have used `cal 73 1 4`.

The second instruction of WALKTOUR.PRG is ALLOCATE. The ALLOCATE instruction tells RATS that the data ends with the fourth quarter of 1990. You will always use ALLOCATE immediately following CALENDAR. If you do not use the CALENDAR instruction, ALLOCATE will be the first statement in your program.
Examples:
For monthly data ending with April 1990 use `allocate 1990:4`.
For monthly data ending with December 1990, use `allocate 1990:12`.
For annual data ending with 1990, use `allocate 1990:1`. The *frequency* (i.e., the number of observations per year) is necessary, even with annual data. You cannot use `allocate 1990`.

The OPEN and DATA statements are used together. The OPEN statement prepares RATS to read the data set named EXRATES.WK1 that is on drive r:\. If the disk is in drive a:\, modify this line of the program and use: a:\exrates.wk1. The DATA statement describes the characteristics of the data set. In this example, `format=wks` indicates that the data set is in a Lotus *.WKS format. The other option used is this handbook is the ASCII *.PRN format. All popular word processing programs and spreadsheets can be used to read and edit ASCII files. The *.PRN and *.WKS formats are used here since they are clearly the most popular.

The option org=obs indicates that the data is organized by observation (instead of organization by variable). The first five rows of the EXRATES.WK1 file can be used to illustrate the structure of *.WKS and *.PRN files organized by observation. Consider:

```
UK        FR    GE        IT        CA        JA
0.992291  0.865777  0.822795  0.924480  0.988696  0.783639
0.948830  0.797379  0.747541  0.946576  0.991403  0.736056
0.968126  0.753772  0.654098  0.941104  0.995339  0.736111
1.009192  0.793454  0.696440  0.941104  0.991304  0.763083
.....    .....     .....     .....     .....     ......
```

Each variable is contained in a column headed by the variable’s name. For example, in 1973:1, the pound/dollar and yen/dollar exchange rate indices were 0.992291 and 0.783639 times their respective base period values. In 1973:2, the pound/dollar and yen/dollar exchange rate indices were 0.948830 and 0.736056, respectively.

Notice the slash (/) in the DATA instruction. In RATS, you can set the range explicitly or use a slash to refer to the default range. Here, RATS reads all series over the entire sample period. A more general syntax for this DATA instruction is:

```
data(format=wks,org=obs) start end series
```

where:  
- `start end` Range of entries to read. The default is the range implied by the CALENDAR and ALLOCATE instructions.
- `series` The list of series to read. If `series` is omitted, all variables in the data set are read into memory.

Examples:
To read only the series `uk` and `ja` over the full sample period, use:
```
data(format=wks,org=obs) / uk ja
```

2 Introduction to RATS
To read only the series *uk* and *ja* over the sample period 1975:1 to 1989:4, use:
```
data(format=wks,org=obs) 75:1 89:4 uk ja
```

To read all series over the sample period 1975:1 to 1989:4, use:
```
data(format=wks,org=obs) 75:1 89:4
```

The next three instructions of WALKTOUR.PRG are:
```
statistics uk
table / uk ja
print / uk ja
```

The STATISTICS and TABLE instructions generate useful information about the data. STATISTICS produces a detailed set of summary statistics on a series you specify. Consider the following output:

### statistics uk

<table>
<thead>
<tr>
<th>Statistics on Series UK</th>
<th>Quarterly Data From 1973:01 To 1990:04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>72</td>
</tr>
<tr>
<td>Sample Mean</td>
<td>1.35109766667</td>
</tr>
<tr>
<td>Variance</td>
<td>0.069768</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.26413543674</td>
</tr>
<tr>
<td>SE of Sample Mean</td>
<td>0.031129</td>
</tr>
<tr>
<td>t-Statistic</td>
<td>43.40366</td>
</tr>
<tr>
<td>Signif Level (Mean=0)</td>
<td>0.00000000000</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.59164</td>
</tr>
<tr>
<td>Signif Level (Sk=0)</td>
<td>0.04477714</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.19332</td>
</tr>
<tr>
<td>Signif Level (Ku=0)</td>
<td>0.74992335</td>
</tr>
</tbody>
</table>

The sample mean and sample variance have straightforward interpretations. The standard error (SE) of the sample mean is the square root of the sample variance divided by the number of observations [i.e., \(\sqrt{0.069768/72}\)] = 0.031129]. The *t*-statistic for the null hypothesis that the mean equals zero is 43.40366 and the significance level for this value of *t* is too low to report.

### table / uk ja

<table>
<thead>
<tr>
<th>Series</th>
<th>Obs</th>
<th>Mean</th>
<th>Std Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>72</td>
<td>1.3510976667</td>
<td>0.26413543674</td>
<td>0.94883000000</td>
<td>2.15473700000</td>
</tr>
<tr>
<td>JA</td>
<td>72</td>
<td>0.61561729167</td>
<td>0.15471136174</td>
<td>0.34800000000</td>
<td>0.84316700000</td>
</tr>
</tbody>
</table>

*Introduction to RATS 3*
The general syntax of the TABLE instruction is:

```
        table start end series
```

where:  

- `start end` The range of entries to use in creating the table. A slash (/) defaults to all observations available for each of the series individually.
- `series` A list of the series to include in the table.

**Examples:**

To obtain a table of `uk` and `ja` using only the sample period 1975:1 to 1989:4, use:

```
        table 75:1 89:4 uk ja
```

To obtain a table of all variables in memory over the sample period 1975:1 to 1989:4, use:

```
        table 75:1 89:4
```

The PRINT instruction has the same syntax as the TABLE instruction. PRINT is a simple way to generate a printout of your data. Consider:

```
        print / uk ja
```

The next four lines in WALKTOUR.PRG use the GRAPH instruction to create a plot of the `uk` and `ja` series against time. The syntax is somewhat different from the others we have encountered since GRAPH requires the use of a supplementary instruction (or “card”) for each series. In RATS, all supplementary cards begin with the pound symbol (#). Also note the use of the dollar sign ($). Although RATS does not have an upper limit on line length, very long lines can be difficult to read. The $ at the end of a line is a continuation character; it indicates that the instruction is continued on the next line below. It is good practice to indent the continuation line so as to maintain the readability of the program. Very long instructions can entail several such continuation lines. Figure 1.1 was created by the statements:

```
        graph(Header='UK and Japanese Exchange Rates (1971:1 = 1.00)', $,
           key=upleft,patterns) 2
```

- `# uk`
- `# ja`

---

4 Introduction to RATS
The typical syntax of the GRAPH instruction is:

```
graph(options) number
# series start end
```

where:
- `number` The number of series to graph. Here, the number 2 tells RATS that two series are to be graphed. The names of the series are indicated on the supplementary cards; there is one such card for each series.
- `series` The name of the series to graph. Remember, there is one supplementary card for each series.
- `start end` Range to plot. If omitted, RATS uses the current sample range.

The graph created here illustrates only a few of the available options. The commonly used options are:

- `HEADER=` A string of characters placed in quotes.
- `KEY=` The location of the KEY. You can use UPLEFT, UPRIGHT, LOLEFT, LORIGHT. The default is none.
- `NODATES` RATS will label the horizontal axis unless the NODATES option is specified.
- `PATTERNS` If PATTERNS is omitted, RATS uses only colors to distinguish between the series. Unless you have a color monitor and printer, you should

---

*Introduction to RATS 5*
use PATTERNS to instruct RATS to use the default pattern style.

**STLYE=** The default style is a line graph. Other popular styles are BAR, VERTICAL (as in high-low-close), and STEP. SYMBOLS draws symbols at regularly spaced intervals along a line; it is an alternative to patterns.

**Examples:**

To create a bar graph of *uk* without a HEADER or KEY, use:

```
graph(style=bar) 1 # uk
```

To create a line graph of *uk* over the full sample period and *ja* beginning with 1980:1, use:

```
graph 2 # uk
    # ja 80:1 90:4
```

The next four instructions in WALKTOUR.PRG illustrate some of the data transformations available in RATS. Each uses the SET instruction to define an entirely new series by transforming one or more of the series already in memory. Consider:

```
set dja 73:2 90:4 = ja(t) - ja(t-1)
set dlja 73:2 90:4 = log(ja(t)) - log(ja(t-1))
set ukja 73:1 90:4 = uk(t)/ja(t)
set time = t
```

The first statement defines *dja* as the first difference of *ja*. The variable *t* in parentheses acts as a time subscript. Thus, for each time period *t* in the interval 1973:2 to 1990:4, *ja(t)* is the value of *ja* in period *t* and *ja(t-1)* is the previous period’s value. The first SET instruction directs RATS to subtract *ja(t-1)* from *ja(t)* and call the resultant series *dja*. With this same logic, the second instruction defines *dlja* as the logarithmic change in *ja*, and the third defines *ukja* as the ratio *uk* to *ja* (i.e., the ratio of the pound/dollar exchange rate to the yen/dollar exchange rate). The last statement defines the variable *time*. Internally, RATS sets *t* = 1 for the starting date of calendar, *t* = 2 for the second entry, and so forth. Since ALLOCATE allows for 72 observations, *time* is the sequence of integers from 1 to 72.

The typical syntax you will use for SET is:

```
set series start end = function(T)
where: series          The name of the series to create.
      start end       The range of the series to set. In newer versions of RATS, a slash (/) or
                        the omission of *start end* both default to the maximum permissible
                        range as indicated on ALLOCATE. If you make a mistake, RATS
                        will create missing values instead of an error message whenever
```

---

6 Introduction to RATS
possible.

\[ = \text{function}(T) \]  

The transformation to use. Note that you must use a space before and after the equal sign. RATS accepts addition (+), subtraction (-), multiplication (*), division (/), and exponentiation (**) using the usual order of precedence. ABS(X), EXP(X), LOG(X), and SQRT(X) are used to denote the absolute value, exponential value (i.e., \(e^x\)), natural logarithm, and square root of the argument X, respectively. All levels of parentheses ( ) are supported but you cannot use braces \{ \} or brackets \[ \] in place of parentheses.

RATS allows you to use braces \{ \} as a shorthand way to represent time subscripts; you can use \text{series}\{lag\} in place of \text{series}(t-lag). For example, instead of using \text{ja}(t-1), you can use \text{ja}{1}. The number placed in the braces \{ \} indicates the lag number. A negative number in braces indicates a leading value of the variable so that \text{ja}(t+2) and \text{ja}{-2} are equivalent ways to write the second lead of \text{ja}. Also, the notation \{A to B\} can be used to indicate lags A through B so that \text{ja}{1 to 4} indicates the first four lags of \text{ja}.

**Examples:**
The following three \text{SET} instructions are equivalent:
\begin{align*}
\text{set dja 73:2 90:4 = ja(t) - ja(t-1),} \\
\text{set dja / = ja - ja(t-1),} \\
\text{set dja = ja - ja{1}.}
\end{align*}

To define \text{jawt} as a declining weighted average of the current and previous three values of \text{ja}, you can use:
\[ \text{set \ / jawt = 0.4*ja + 0.3*ja{1} + 0.2*ja{2} + 0.1*ja(t-3).} \]

A series can be written on to itself. The instruction \text{set ja = log(ja)} replaces each entry in \text{ja} by its natural logarithm.

Time-series analysis uses logarithmic transformations and differencing so frequently that RATS contains special instructions for these transformations. The \text{DIFFERENCE} and \text{LOG} instructions are usually used as follows:

\begin{align*}
\log \text{ja / lja} \\
\text{difference ja / dja}
\end{align*}

The interpretation of these two instructions is straightforward. The first defines \text{lja} as the logarithm of \text{ja}. Thus, \text{log ja lja} is equivalent to \text{set lja 73:1 90:4 = log(ja)}. Similarly, the second instruction defines \text{dja} as the first difference of \text{ja}. Since you can abbreviate a RATS instruction by its first three letters, \text{dif ja / dja} is equivalent to \text{set dja 73:2 90:4 = ja(t) - ja(t-1)}. You must define the \text{start end} range or use the slash (/) on the \text{DIFFERENCE} statement. Unlike the \text{SET} statement, if you explicitly define the range, you must allow for the number of lags created.
Linear Regression

The LINREG instruction is the backbone of RATS and it is necessary to illustrate its use. As such, suppose you want to estimate the logarithmic change in the yen/dollar exchange rate as the fourth-order autoregressive process:

$$dlja_i = a_0 + a_1 dlja_{i-1} + a_2 dlja_{i-2} + a_3 dlja_{i-3} + a_4 dlja_{i-4} + e_i$$

where $dlja_i$ is the logarithmic change in the yen/dollar exchange rate in period $i$, $e_i$ is the error term, and the $a_i$ are regression coefficients. The next two lines in WALKTOUR.PRG estimate the model using ordinary least squares (OLS):

linreg dlja

# constant dlja{1 to 4}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff</th>
<th>Std Error</th>
<th>T-Stat</th>
<th>Signif</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Constant</td>
<td>-0.008597770</td>
<td>0.006515433</td>
<td>-1.31960</td>
<td>0.19182055</td>
</tr>
<tr>
<td>2. DLJA{1}</td>
<td>0.380057577</td>
<td>0.127409984</td>
<td>2.98295</td>
<td>0.00407824</td>
</tr>
<tr>
<td>3. DLJA{2}</td>
<td>-0.069354210</td>
<td>0.136191749</td>
<td>-0.50924</td>
<td>0.61239211</td>
</tr>
<tr>
<td>4. DLJA{3}</td>
<td>0.132964297</td>
<td>0.137935694</td>
<td>0.96396</td>
<td>0.33881154</td>
</tr>
<tr>
<td>5. DLJA{4}</td>
<td>-0.087810729</td>
<td>0.129181480</td>
<td>-0.67975</td>
<td>0.49919483</td>
</tr>
</tbody>
</table>

Notice that the estimation begins in 1974:2; RATS automatically adjusts for the five observations lost due to differencing and the use of four lags. As such, there are 67 usable observations ($72 - 5 = 67$); given the five parameters estimated, there are $67 - 5 = 62$ degrees of freedom. Next, RATS reports four Goodness-of-Fit measures: centered $R^2$, $R$-bar square (centered $R^2$ adjusted for degrees of freedom), uncentered $R^2$, and $TR^2$ (number of observations
Let the dependent variable be denoted by \( y \). Uncentered \( R^2 \) is \( 1 - \frac{\text{sum of squared regression residuals}}{\text{sum of squared values of } y} \). Centered \( R^2 \) is \( 1 - \frac{\text{sum of squared regression residuals}}{\text{sum of squared deviations of } y \text{ from the mean of } y} \). The so-called “usual” \( R^2 \) statistic is the centered \( R^2 \).

For each right-hand-side variable, the next portion of the output reports the coefficient estimate (Coeff), the standard error of the coefficient (Std Error), the \( t \)-statistic for the null hypothesis that the coefficient equals zero (T-Stat), and the marginal significance level of the \( t \)-test (Signif). For example, the coefficient of the first lag of \( dlja \) is estimated to be 0.380057577 with a standard error of 0.127409984. The associated \( t \)-test for the null hypothesis \( a_1 = 0 \) is \( \frac{0.380057577}{0.127409984} = 2.98295 \). If you use a \( t \)-table, you can verify that the significance level for this value of \( t \) is 0.00407824. If you want to use a one-tail test, the appropriate significance level is twice that reported.

This particular regression does not look especially good; the individual \( t \)-statistics suggest that all but one of the coefficients are insignificant at conventional significance levels. The EXCLUDE instruction allows you to perform hypothesis tests on several coefficients at once. EXCLUDE is followed by a supplementary card listing the variables to exclude from the most recently estimated regression. RATS produces the \( F \)-statistic and the significance level for the null hypothesis that the coefficients of all excluded variables equal zero. Consider:

```
exclude # constant dlja{2 to 4}
```

Null Hypothesis: The Following Coefficients Are Zero
Constant  DLJA Lag(s) 2 to 4
F(4,62) = 0.72028 with Significance Level 0.58133419

The exclusion restriction tests the joint hypothesis \( a_0 = a_2 = a_3 = a_4 = 0 \). The results support those of the \( t \)-tests; neither of these null hypotheses can be rejected at conventional significance levels.

---

1 Let the dependent variable be denoted by \( y \). Uncentered \( R^2 \) is \( 1 - \frac{\text{sum of squared regression residuals}}{\text{sum of squared values of } y} \). Centered \( R^2 \) is \( 1 - \frac{\text{sum of squared regression residuals}}{\text{sum of squared deviations of } y \text{ from the mean of } y} \). The so-called “usual” \( R^2 \) statistic is the centered \( R^2 \).