HowToReadMathematica

Empirical Market Microstructure

(2006, Oxford University Press)

Companion Mathematica notebook

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This notebook is a primer for reading Mathematica notebooks.

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Rules

Most Mathematica notation mimics normal usage. The major difference is the equals sign. Suppose that we encounter the following two equations in text:

\[ m_t = m_{t-1} + u_t \]  
\[ p_t = m_t + c q_t \]

Intuitively, we know that these are describing dynamics of some time-subscripted variables. These equations are really "rules" for generating successive realizations of \( m_t \) and \( p_t \). In Mathematica, equation (1) would be written as;

\[ m_t \rightarrow m_{t-1} + u_t \]

\[ m_{t-1} + u_t \]

The blue background signals that this line is input to Mathematica, rather than simply text. The beige background identifies Mathematica output. The notation \( \rightarrow \) (or sometimes \( \rightarrow \)) means "replace the left-hand side with the right-hand side". The \( t_\) on the left-hand side of the rule is a pattern (template) that allows use to apply the rule to \( m_{t-5}, m_{xyz} \) or \( m_{whatever} \), not just \( m_t \). To apply the rule, we use the notation "/. "_. For example:

\[ m_t /\ m_{t-} \rightarrow m_{t-1} + u_t \]

\[ m_{-1+t} + u_t \]
Note that *Mathematica* writes expressions with numbers before variables: $-1 + t$ rather than $t - 1$. Similarly:

```
m_{t,5} \rightarrow m_{t-1} + u_t
```

Mathematica doesn't really know that $t$ indexes time, of course:

```
m_{\text{whatever}} \rightarrow m_{t-1} + u_t
```

The text expression for $m_t$ has a label "(1)" that allows us to subsequently refer to the rule. In *Mathematica*, we assign the rule to a variable:

```
m_{\text{Rule}} = m_{t} \rightarrow m_{t-1} + u_{t};
```

The semicolon at the end of the line suppresses output. Now a reference to $m_{\text{Rule}}$ invokes the rule we just defined. E.g.:

```
m_{t} \rightarrow m_{\text{Rule}}
```

We can apply the rule repeatedly:

```
m_{t} \rightarrow m_{\text{Rule}} \rightarrow m_{\text{Rule}} \rightarrow m_{\text{Rule}}
```

And so forth. Here's another rule

```
P_{\text{Rule}} = P_{t} \rightarrow m_{t} + c_q t;
```

Applying the rules in succession:

```
P_{t} \rightarrow P_{\text{Rule}} \rightarrow m_{\text{Rule}}
```

We can use rules in defining other rules. Here's an expression for the first difference:

```
\Delta P_{\text{Rule}} = \Delta P_{t} \rightarrow (P_{t} \rightarrow P_{\text{Rule}} \rightarrow m_{\text{Rule}}) - (P_{t-1} \rightarrow P_{\text{Rule}});
```

For example:

```
\Delta P_{t} \rightarrow \Delta P_{\text{Rule}}
```

$-c_q q_{t-1} + c_q t + u_t$
Equations and "=="

We also use equal signs to set up equations. *Mathematica* uses the double-equal sign in this context. For example:

\[
\text{Solve}[0 == a \, x^2 + b \, x + c, \, x]
\]

\[
\{\{x \rightarrow \frac{-b + \sqrt{b^2 - 4 \, a \, c}}{2 \, a}\}, \{x \rightarrow -\frac{b + \sqrt{b^2 - 4 \, a \, c}}{2 \, a}\}\}
\]