Visualization Technique for Linked Changes in Exchange Rates Between Three Currencies

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Abstract

A line chart is mainly used to represent the change in exchange rate between two currencies. To figure out the trend of the exchange rate between two currencies, it is important to understand how the two currencies move in relation to another currency. We developed as a new visualization technique, called a linked triangle chart, for representing linked nature of exchange rate changes between three currencies. The linked triangle chart uses the coordinate system of a triangular chart. In this paper, we describe this new chart and Eel, a tool implementing it. From trials, we confirmed that some events which are difficult to find on a line chart become obvious on the linked triangle chart.

Keywords: Information Visualization, Foreign Exchange Rate, Triangular Chart

1   Introduction

A line chart is usually used to represent of the change in the exchange rate between two currencies. It is a suitable representation for representing binomial changes. A reader can intuitively grasp the exchange rate fluctuations. However, to understand the general trend in the exchange rate between two currencies, it is important to understand their moves in relation to a third currency. The important aspect here is that the three currencies' exchange rates do not change individually, but rather collectively.

When we compare exchange rate changes of three currencies, we can align or pile up three line charts. However, these methods are not easy ways to grasp exchange rate changes. They cannot represent the linked nature of these changes.

Purpose of our research is to develop a new visualization technique to represent linked transitions in the exchange rates between three currencies. In this paper, we introduce the notion of a linked triangle chart and Eel, a software tool implementing it.

2   Charts representing trinomial relations

Line charts and triangular charts can be used to represent trinomial relations but they have limitations. In this section, we discuss these charts.

2.1   Line Chart

Line charts are suitable for visualizing continuous value variations. For example, they are good for visualizing the time variation of the population of a city. The advantage of line charts is that it is easy to see transition and tendency of the value. However, this advantage is had when there is only one data variable. A line chart is not always suitable when there are three data variables. To visualize a trinomial relation, we have to align or pile up three line charts. Aligning three charts is a not an easy way of representing trinomial relations because a reader has to compare three charts. Piling up three charts is suitable when the units of three variables are the same. However, when the units are different, the piling task is not so simple. While we can represent the variables on three axes, a line chart with three axes is still difficult to read.

We show an example of making units consistent in Fig. 1. The x-axis in this figure represents time, and the y-axis represents rate of change, with no change represented as 100%. The rate of change is the ratio of the value at the current time point to the value at the base time point. When we look at each line, we can grasp the tendency of the individual exchange rates. However, it is important to remember that the exchange rates of the three currencies do not change individually, but rather collectively; perceiving this linked nature is rather difficult in this chart.
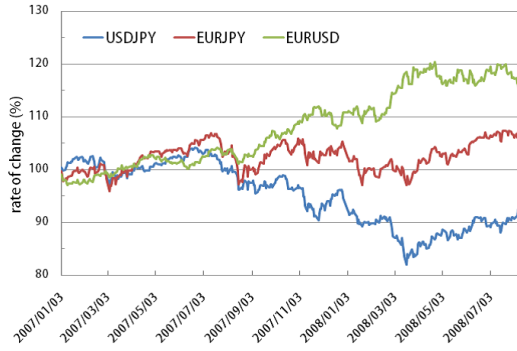
Figure 1. A line chart representing of the change in exchange rates between three currencies. USD/JPY, EUR/JPY and EUR/USD rates of change are plotted.

2.2 Triangular Charts

A triangular chart is a chart that utilizes the features of regular triangles whereby the sum of perpendicular line lengths from any point inside the triangle to each side is always the same length [2]. For example, this chart is used for representing the population composition of primary, secondary and tertiary industries, or for component classification of soil. The advantage of the triangular chart is evident in representing trinomial relations because charts which can represent trinomial relation in two-dimensions are rare. On the other hand, the disadvantage is that only the composition rates of three elements can be visualized.

The relations between three currencies cannot be represented by a triangular chart because it is not a composition rate of three elements. However, that a triangular chart can represent trinomial relation is an attractive point. We decided to adopt the coordinate system of a triangular chart as a coordinate system for our new visualization technique.

3 Linked Triangle Chart

The linked triangle chart (LTC) is a visualization technique whose purpose is representing linked transitions of exchange rates between three currencies, which cannot be represented by a line chart. In this section, we describe the LTC's visualization method, data format, drawing procedure, and knowledge that can be obtained from this chart.

3.1 Visualization Method

LTCs are based on the coordinate system of triangular charts. Three elements are drawn on three vertices of the triangle. The sides joining each vertex are drawn and they represent binomial relations. A triangle joining these three binomial relations is also drawn, and the barycenter of this second triangle is drawn to represent the linked transition of the three elements. Concretely speaking, three countries are drawn on the three vertices of the triangle. Next, currency points representing the exchange rate between two currencies are put on sides joining each vertex. Finally, a barycenter of the triangle of currency points (currency barycenter) is drawn and it represents the transition of the exchange rate between three currencies.

3.2 Data Format

Three currencies have different units. As described in Sect. 2.1, a line chart needs three axes to represent three elements whose units are different. Such a chart is not easy to read. Therefore, we tried to a make the units of data consistent in a way that would resolve this problem.

As a way of making the units consistent, we adopted the rate of change of the exchange rate. Let us explain this value. If the exchange rate at the base time point τ_0 is $V(\tau_0)$ and the exchange rate at a certain time point τ_n is $V(\tau_n)$, and the rate of change of the exchange rate $R(\tau_n)$ at the certain time point τ_n is:

$$R(\tau_n) = \frac{V(\tau_n)}{V(\tau_0)} \times 100$$

By using this rate, it is easy for a reader to read out the chart.

3.3 Drawing Procedure

The drawing procedure is as follows.

(1) Draw a regular triangle and assign one country to a vertex (Fig. 2(a)).

(2) Plot the rate of change between the two currencies (currency point) on a segment joining the two vertices. A rate of change of 100% means that the currency exchange rate has not changed and it is plotted at the center of the segment. When rate is not 100%, the currency point is plotted closer to one of the vertices (Fig. 2(b)).

(3) Create a triangle whose vertices are the three currency points and plot the currency barycenter of this triangle (Fig. 2(c)).
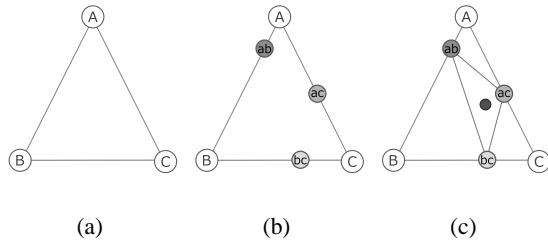

Figure 2. Drawing procedure. (a) Draw one country on each vertex of the triangle. (b) Plot a currency point on a segment joining two vertices. (c) Create a triangle whose vertices are the three currency points and plot the currency barycenter of this triangle.

3.4 Visualized Knowledge

The sides of the LTC visualize the rate of change in the exchange rate between two currencies. If a currency point is at the center of a side, the reader can understand that there is no change in exchange rate. If a currency point is closer to one of the vertices, the reader can understand that the currency value of one country is high. For example, in Fig. 2(c), currency point *ac* represents no change from the base time point, whereas *ab* represents a change where currency value of country *A* rises.

A reader can see the linked transition between three currencies by looking at the currency barycenter. The barycenter on the base time point τ_0 coincides with a barycenter of the country triangle (the main triangle). Consequently, the tendency of the three currencies is represented as currency barycenter in relation to the barycenter of the country triangle. For example, the currency barycenter is far from country *B* in Fig. 2(c). This represents that currency value of country *B* is decreasing against currency of the other two countries.

In addition, by showing trajectory of the currency barycenter, a reader can see the time transition of exchange rates of the three currencies. This trajectory is an easy way to understand linkage between three currencies.

4 Eel

Eel is an application implementing LTCs. Note that the data mentioned in this section are exchange rates between three currencies, i.e., JPY, USD and EUR.

4.1 Basic Design

Figure 3 is a screenshot of Eel. The left side of the figure shows the LTC, and the right side shows a line chart.

The x-axis of the line chart is time, and the y-axis is rate of change of the exchange rate. Three lines represent the rates of change between two currencies and are identified by their color. There is a clock icon on the x-axis and a vertical line from the icon toward the y-axis direction. This icon means the time shown on the LTC. The user can make the LTC display data for different times by moving the icon.

The LTC has country flags on the vertices. The colors of the currency points correspond to the colors of the line chart. Rate labels are displayed next to the flags. The values of the labels are maximum or minimum rates. The system compares $maximum\ value - 100$ with $100 - minimum\ value$, and the larger value is taken as the label value. Therefore, the center of the label is always 100, but the label value can be changed if the base time point changes. Currency values and rates are displayed in color at the tops of the line chart and LTC.

We debated about whether to put the time line under the LTC, but decided that it would be more effective if the LTC were accompanied with a line chart because a lot of people are used to line charts. We concluded that putting a time line under the LTC was not an intuitive design because the LTC cannot represent the time axis intrinsically. For this reason, we put the clock icon only on the line chart.

The left side of the panel shows menus for setting parameters, changing the display mode, and so on. The next section describes some of the operations.

4.2 Main Functions

4.2.1 Displaying Trajectories

The LTC can display the trajectories of currencies. Figure 4 is a screenshot displaying a trajectory.
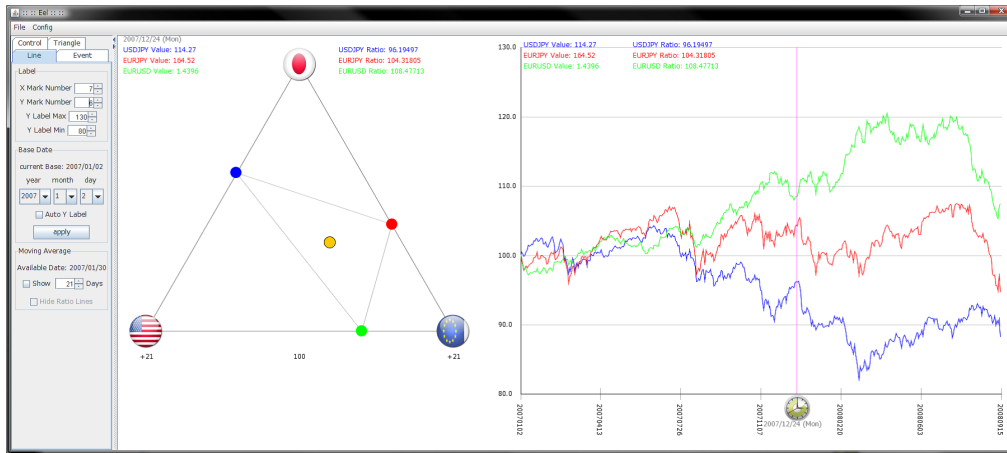
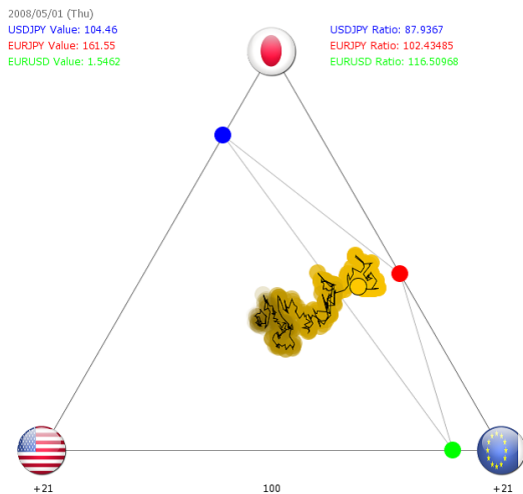Figure 3. Eel: an application of linked triangle charts.

Figure 4. Screenshot displaying trajectory of currency barycenter.

The age of the trajectory is represented by the brightness of a color. As the trajectory gets older, the color becomes darker.

However, by changing only the brightness, the place where the old trajectory lingers turns completely black. Therefore, we are planning to increase the transparency as the trajectory gets older. This would help the viewer to see the trajectory better.

The length of the trajectory can be set freely by using a slider. Eel can show an intuitive visualization of three currencies' linkage by displaying the trajectory of the currencies' barycenter.

4.2.2 Displaying Moving Averages

Eel can also show moving averages. A moving average is the unweighted mean of the previ-
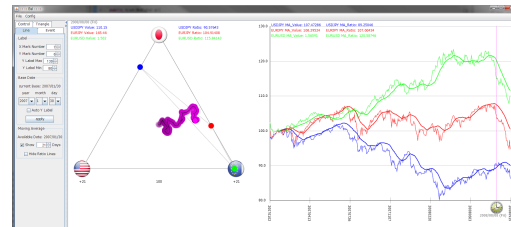

Figure 5. Screenshot displaying moving average.

ous n data points. This is used for finding tendencies. Figure 5 shows a screenshot of Eel displaying moving average. Line charts draw moving average lines on rate lines as bold lines (rate lines are optionally invisible), whereas linked triangle charts show only moving average lines. This is because we believe that displaying moving average lines over rate lines complicates the chart presentation and decreases its readability.

Figure 5 shows 21-day moving averages. The reader can freely change the term of the moving average from 2 to 999 days.

4.2.3 Changing base time point

There are many situations in which a reader would want to change the base time point. For example, when a reader wants to check the effect of a financial event on something, he/she should set the base time point to the day the event occurred. There are two ways to change the base time point. The first is to select a date from the left panel. This is good for when the base time point that the reader wants to set has already been decided. The other way is to use the clock icon on the line chart. A pop-up menu is displayed when the reader right clicks on the clock
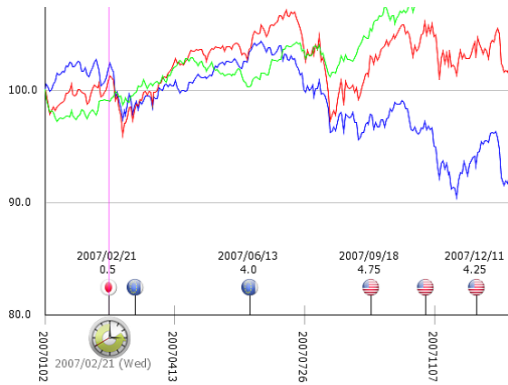
Figure 6. Screenshot displaying events

icon. The reader selects the base time point selection item from this menu, and the base time point is set to the time point displayed by the clock icon. This is good for when the reader wants to check a certain point in time that is of interest to him/her.

4.2.4 Displaying Events

The trend of policy rates and megabanks often affect financial products. Therefore, we implemented a function to show financial events. Figure 6 shows a screenshot displaying such events.

The country flag icons in Fig. 6 are shown on the time line when their policy rates change. Clicking on a flag icon displays the change date and value of the policy rate.

5 Discussion

5.1 Comparison of Three Chart Types

The similarities and differences between linked triangle charts and triangular charts are as follows. Both charts use a triangular coordinate system. The triangular coordinates are one of a handful coordinates that can represent a trinomial relation. The linked triangle chart can represent three pairs of relations, i.e., each paired combination of three items. Moreover, it can represent the linked transitions of three pairs of relations. In contrast, a triangular chart can represent only trinomial ratios.

Table1 lists the upsides and a downsides of linked triangle charts, line charts, and triangular charts.

5.2 Results of trial use of Eel

We confirmed that the linked triangle chart provides a more intuitive presentation of the change in trinomial relations, in comparison with a line chart. When a reader analyzes the data by using a line chart, he/she has to check the correspondence between lines and currencies. Hence, he/she wastes time for analysis because he/she has to remember correspondence relation of lines while analyzing. On the other hand, when a reader uses a linked triangle chart, he/she can easily analyze the trend because he/she can grasp the relation between the currency point and the change in the currency point.

We confirmed that the linked triangle chart does not affect the readability of the chart when the base time point changes, unlike the case of a line chart in which the line often moves very much when the base time point changes. This fosters the illusion in the reader's mind that the data is completely different. In the linked triangle chart, the positions of currency points and currency barycenter move but the shape of the trajectory does not change. This means the linked triangle chart helps the reader not to misread the data more than a line chart does.

We confirmed that the trajectory of the currency barycenter shows the linked nature of the three currencies. The reader cannot grasp this nature by looking at a line chart. Figure 7 is a screenshot illustrating the linked nature in the form of a five-day moving average. We found that the trajectory moves while turning in counterclockwise in many cases. This movement shows that the exchange rates change as follows: $\cdots \Rightarrow$ USD low $\Rightarrow$ JPY high or EUR low $\Rightarrow$ USD high $\Rightarrow$ JPY low or EUR high $\Rightarrow$ USD low $\Rightarrow \cdots$. Although we can not see the causation, we at least can see that there is a linked nature. In contrast, it is difficult to see the linked nature in the line chart in the lower left of Fig. 7.

The above results indicate that we can obtain new information from linked triangle charts.

6 Related Work

Lin et al. [3] developed a visualization technique to observe very large and high-density streams in a limited frame. They visualized large-scale data on two currencies by using a fish-eye view. In contrast, we visualize linked transitions in the exchange rates between three currencies.

Gresh et al. [1] researched visual presentation of FX options. Their purpose was to create an interactive visual environment that allows an analyst to explore complex interactions and views

Table 1. Upside and downside of three charts. (LTC: linked triangle chart, LC: line chart, TC: triangular chart)

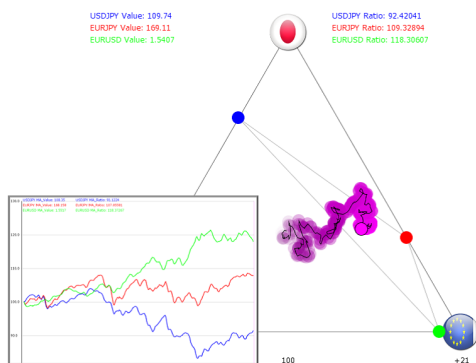| Chart type	Upside	Downside
LTC	can represent linked transition between three pairs of relations	does not have a coordinate axis that represents time
LC	has a coordinate axis which represents time	cannot represent linked transition of multiple binomial relations
TC	can represent trinomial ratios	does not have a coordinate axis that represents time

Figure 7. Eel representing a five-day moving average. The trajectory moves while turning in counterclockwise in many cases.

for communicating information to non-analysts. While they focused on options, we focus on data relating three currencies.

Tani et al. [4] proposed a subjective visualization method for intuitively understanding the exchange rate environment. They used neural networks for intuitive reasoning and created subjective environment maps. The purpose of their research was to visualize the exchange rate environment. On the other hand, the purpose of our research is to visualize the linked transitions in the exchange rates between three currencies.

7   Conclusions and Future Work

We focused on the linked nature of exchange rates between three currencies, which a reader cannot easily perceive from viewing a line chart. To visualize it, we developed a new visualization technique called the linked triangle chart. A linked triangle chart uses the coordinate system of a triangular chart. Three countries ' currencies are drawn on three vertices of the triangle, sides linking each vertex represent the exchange rate between two currencies. A reader of such

a chart can see the linked nature between three currencies intuitively. We developed a software application (Eel) that implements linked triangle charts. From the trials of Eel, we confirmed that some events which are difficult to perceive from line charts are revealed on linked triangle charts.

In the future, we will quantitatively evaluate the efficiency of linked triangle charts in an experiment. In addition, we will also discuss applications to other data.

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