Programming 5061 Data Translation Challenge

Business Problem—Risk of Loss

FXB Bank is no stranger to risk. It trades on its own account and takes positions, occasionally massive ones, on various currency exchanges. It also trades foreign exchange options with its customers. These accumulated option positions also contribute to the bank's foreign exchange risk. While FXB intentionally takes on risk, the management of the bank and its various government regulators across the globe require that it anticipate possible catastrophic losses and hold adequate reserves to maintain liquidity in those circumstances. For this reason, they run a nightly ***risk of loss simulation*** against its current positions.

The positions of the bank are in various contracts and other instruments, some of them unique, complex, and highly tailored to their clientele, and each of these would need to be modeled correctly for the simulation to be accurate. But for our first version of the simulation, management is content with initially modeling all the bank's positions as a collection of the following instruments:

**Foreign exchange spot position** in a liquidly-traded direct market. For example, a EUR spot position is essentially a bank account denominated in European Union Euros. Since FXB Bank is a dollar-based company, the value of these EUR deposits in USD is determined by the current EUR/USD exchange rate, which is determined collectively by the active participants in that market. We have lots of current and historical data on these exchange rates and can easily gather the current exchange rate and data about its volatility (i.e., the standard deviation of the percentage change of the exchange rate from day to day).

These liquid markets for FXB Bank are:

* EUR (European Euro), traded as euros priced in dollars (EUR/USD),
* GBP (British Pounds), traded as pounds priced in dollars (GBP/USD), also know as "cable",
* JPY (Japanese Yen), traded as dollars priced in yen (USD/JPY),
* CHF (Swiss Franc), traded as dollars priced in francs (USD/CHF), and
* AUD (Australian Dollar), traded as AUD priced in USD (AUD/USD).

Data for each of these is given as:

* current exchange rate (either dollars per foreign unit or vice versa, depending on the market as indicated above), and
* volatility, which is the standard deviation of logarithmic returns
* **Three-month foreign exchange options.**These are contracts that allow one of the parties to force an exchange of two given currencies at a given rate on the expiration date three months from now. Options are described in more detail in [P5: Foreign Exchange Option](https://seattleu.instructure.com/courses/1601538/assignments/6975680) and, indeed, we'll use the valuation function from that project. For our purposes here, FXB will approximate all it's non-linear foreign exchange risk as options that are struck at-the-money (i..e., current spot exchange rate) and expiring 90 days from now.

### Analysis

There are many methodologies for Value at Risk (VAR) analysis. One such analysis would be to replay historical foreign exchange daily movements (as percentage changes), apply them to today, and then valuing our positions against that day's movements. The tenth worst such day of playing four years of daily history (about 1000 days) would be considered our 99% VAR. This is often called the historical VAR method. This method has the advantage of being simple and takes into account implied correlations between the different currency prices. Downside is that it requires daily historical data and doesn't model catastrophic events where the historical correlations break down.

Instead, we will use a simplified version of what's typically called a **Monte Carlo VAR** method. We will assume each of the currency movements is independent of the others and consider various scenarios where one or more of the currency exchange rates moves dramatically up or down. For each scenario we will re-value our positions and then report on the scenarios where we saw the worst outcomes for the bank.

For each of our currencies, we will do one of the following:

* move it down overnight by three standard deviations,
* move it down overnight by one standard deviation,
* leave it flat overnight,
* move it up overnight by one standard deviation, or
* move it up overnight by three standard deviations.

We will analyze all 3125 possible scenarios for various combinations of the above moves for each of the five currency exchange rates.

Do note however, that if various scenarios have the exact same loss, then discard the more extreme scenarios that do not change the result.

In test1 data set, our worst loss is $6.32918 billion with moves  {'EUR': -3, 'GBP': 1, 'JPY': 3, 'CHF': -3, 'AUD': -3}.

### Communication

Once the analysis is complete, we will communicate the results daily to the management and as required to the various regulators. Our report will be in the form of a bar chart showing the worst scenario of overnight risk.

For example, from the test1 data set we'd get this result:

Chart

Description automatically generated