



Simio December  
2017 Student  
Competition

Managing  
Intra-day Liquidity  
Risk in Banking



Forward Thinking

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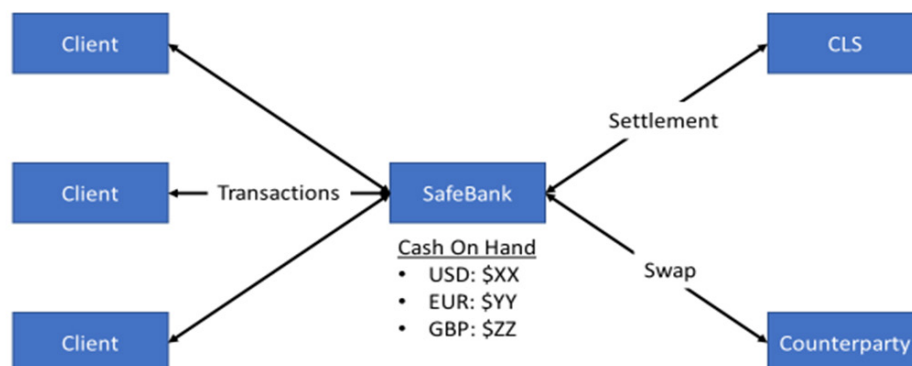
# Problem Overview

SafeBank is a major custodian bank in the global financial market. One of the services SafeBank provides is changing currencies for their clients. For example, if a client wants to buy equity in a German company denominated in EUR, and the client wants to spend USD, SafeBank will take the USD and give out EUR, which allows the client to conduct their transaction. SafeBank makes money by charging the client a small percentage on each exchange. There are thousands of random, unpredictable transactions every day, and they require SafeBank to hold cash in each type of currency. At the end of each day (6:30PM ET), SafeBank conducts a settlement with CLS Bank (Continuously Linked Settlement Bank) to reset the quantities of each type of currency. For example, if over the course of the day the sum of all transactions causes SafeBank to have a net increase in USD and a net decrease in EUR, they will give the excess USD to CLS and CLS will return the equivalent amount of EUR. CLS charges SafeBank a small percentage on this exchange. This confines the risk to SafeBank to a single day (known as intra-day liquidity risk). If SafeBank runs out of any type of currency prior to 6:30pm ET, they can conduct a swap with one of their counterparties. This is essentially the same service provided by CLS, but it can occur anytime throughout the day. Swaps help mitigate risk, but they are expensive relative to CLS.

In addition to financial considerations, SafeBank is legally obligated to manage risk. If they are unable to support client transactions for any reason, it can cause a major disruption in the global financial market. Accordingly, they must prove to the government that they have sufficient cash on hand to avoid this situation across a range of stressing scenarios. Choosing the amount of each type of currency to keep on hand is a difficult problem. Students will be asked to simulate system activity (e.g., cash flows from transactions, swaps, and settlements) to find the profit maximizing quantities subject to acceptable risk. This will include analysis of revenue, cost, and risk. These analyses will be completed across a range of scenarios including:

- Business as usual
- A market trend towards one type of currency and away from another
- Loss of a counterparty (i.e., no ability to swap mid-day)

For purposes of this problem, students will be asked to consider 3 types of currency: USD, EUR, GBP. A basic system representation is shown below:



# System Information

Your goal is to choose profit maximizing quantities of cash on hand for SafeBank, subject to acceptable risk. Specifically, you need to set a target for how much cash in each of the three currencies (USD, EUR, GBP) SafeBank needs to start their day. To do this, you will have to model the random client transactions that occur throughout the trading day. Currency markets are open 24/7. However, most currency transactions are the result of movement in financial markets. For the purposes of your model, you can assume that a trading day starts at 8am and ends at 6:30pm. At the end of the day, SafeBank will conduct a settlement with CLS Bank to reset their cash values to the same amount they started with.

SafeBank has 30 major clients. They range in size from \$700bn to \$1400bn in terms of assets under management (AUM). Below is a sanitized list of the clients and their sizes:

ClientNumber	Total assets under management (USD)
1	\$ 1,301,475,193,000.00
2	\$ 1,226,812,617,000.00
3	\$ 1,225,388,000,000.00
4	\$ 758,165,858,000.00
5	\$ 1,219,923,339,000.00
6	\$ 1,231,706,044,000.00
7	\$ 734,649,952,000.00
8	\$ 1,274,308,204,000.00
9	\$ 955,405,562,000.00
10	\$ 1,224,379,459,000.00
11	\$ 832,993,128,000.00
12	\$ 961,288,554,000.00
13	\$ 1,290,568,342,000.00
14	\$ 1,131,041,236,000.00
15	\$ 1,269,707,564,000.00
16	\$ 710,138,698,000.00
17	\$ 1,256,595,766,000.00
18	\$ 1,388,192,358,000.00
19	\$ 1,222,491,698,000.00
20	\$ 1,247,918,733,000.00
21	\$ 889,373,551,000.00
22	\$ 1,191,850,256,000.00
23	\$ 1,386,649,639,000.00
24	\$ 1,027,224,072,000.00
25	\$ 1,300,240,580,000.00
26	\$ 803,555,136,000.00
27	\$ 1,028,076,299,000.00
28	\$ 1,188,003,259,000.00
29	\$ 1,085,151,825,000.00
30	\$ 1,235,185,564,000.00



You've conducted several interviews with experts from the bank and learned that clients will typically move anywhere from 1-2% of their AUM in a normal day. This movement occurs over thousands of transactions which vary in size and in currency. Some experts suggested that most transactions are less than \$10M and you should focus on those. Others cited recent transactions greater than \$100M and suggested that you focus on those. Luckily, SafeBank was kind enough to provide you with several randomly selected days of their transaction data:

[http://cdn.simio.com/StudentCompetition/2017DecStudentProblem\\_TransactionData.xlsx](http://cdn.simio.com/StudentCompetition/2017DecStudentProblem_TransactionData.xlsx)

As you process the data, please answer the following questions:

1. How did you model the interarrival time of the transactions?
2. How did you model size of the transactions?
3. How did you model the proportion of transactions in each type of currency?

The exchange rate doesn't change significantly over the course of a single day, but it does change over year. Below are some graphs that show how exchange rates have fluctuated over the last year:

15 Aug 2017 22:10 UTC USD/EUR close:0.85202



16 Aug 2016 00:00 UTC - 16 Aug 2017 21:06 UTC USD/GBP close:0.77599 low:0.74491 high:0.83174



4. How did you model the exchange rate?

SafeBank charges a small fee for each transaction that occurs. The fee is 0.02% of the transaction (also known as 2 basis points). The fee is in addition to the transaction amount, so it does not reduce the transaction size in any way. SafeBank is a US company, so their revenue should always be denominated in USD.

At 6:30pm, SafeBank settles with CLS Bank. The purpose is to reset the cash on hand for each currency to the target value. If, for example, SafeBank has accumulated \$1bn EUR above their target and has given out the equivalent amount of GBP, they will give the excess EUR to CLS. CLS gives back the equivalent amount of GBP, resetting SafeBank to their target values. CLS charges SafeBank 0.01% or 1 basis point for this service.

SafeBank also has a counterparty called GloboBank. If SafeBank runs low on cash anytime during the day, they can conduct a swap with GloboBank. This is similar to the end of day settlement, except that SafeBank doesn't necessarily reset cash values to their target. It will be up to you to determine the triggering threshold for a swap, the amount, and the currency that should be traded in. While other transactions can be treated as instantaneous, swaps take time. Somebody first recognizes that cash is low, and flags it to a decision maker. The decision maker contacts GloboBank to make a deal. Once the deal has been agreed upon, the swap occurs. This entire process takes about 30 minutes, with a standard deviation of 2 minutes. Therefore, the trigger needs to occur with enough time to complete the swap before cash runs out. Swaps help mitigate risk, but they are also expensive. GloboBank charges 0.5% or 50 basis points.

The final cost to consider is opportunity cost. SafeBank could carry lots of extra cash and avoid expensive swaps. However, this strategy would leave cash stranded. On average, the rest of their business has a return on investment (ROI) of 8% per year. For example, if SafeBank carries \$1bn USD more than they need for a year, they are losing an \$80M opportunity. Even though opportunity cost does not technically cause cash to leave their system, treat it as such for your analysis.

SafeBank is federally regulated. If they are unable to support client transactions for any reason, it can cause a major disruption in the global financial market. Accordingly, they must prove to the government that they have sufficient cash on hand to avoid this situation. This is accomplished through stress tests. Interestingly, the government does not write or conduct the test. It is up to SafeBank to test themselves and then explain both the test and the outcome. Part of your model must include tracking the minimum levels of cash on hand in each type of currency. Zero risk means that if the cash drops to zero in any of the replications, the test is failed. It is up to you to determine the appropriate number of replications to run. As a reference point, if you can show that the probability of running out of cash is less than 0.01% the government will accept your results.

# Analysis

As mentioned above, your objective is to choose profit maximizing quantities of cash on hand subject to the risk constraints. This will require a handful of important decisions:

- Cash on hand to start each day (use increments of 1bn)
  - USD
  - EUR
  - GBP
- Swap policy (use increments of 0.5bn)
  - Trigger point for each type of currency
  - Swap amount for each type of currency

You will also have to track several outcome metrics, including:

- Minimum inventory levels for each type of cash (i.e., risk)
- Revenue from transactions
- Cost from settlements and swaps
- Opportunity cost
- Profit

There are several scenarios that you are required to test. The scenarios will likely change the amount of cash on hand. Please put your answers into the following table format:

Scenario	USD on hand	USD swap trigger point	USD swap amount	EUR on hand	EUR swap trigger point	EUR swap amount	GBP on hand	GBP swap trigger point	GBP swap amount	Revenue	Cost	Profit
Scenario1												
Scenario2												

The scenarios are as follows:

## Business as usual (BAU)

Given the system information above, determine the profit maximizing cash on hand and swap policy. Be sure discuss the key outcome metrics.

The bank does not currently have a model like the one you've built. They choose the amount of cash on hand by looking at the largest net change in currency caused by a single client at any point throughout the day. The bank multiplies this number by 30 to approximate the worst-case scenario accounting for all clients. Using this method, SafeBank determined that it should hold \$30bn USD, \$20bn EUR, and \$10bn GBP. How does this answer compare to yours? Why are they different? What would you tell the bank to convince them to adopt your method?

Additionally, SafeBank does not have much appetite for risk. They would also like to know how much extra cost is incurred to make sure they have at least \$1bn on hand at any time in each type of currency. What would you tell them?

### **Trend away from one type of currency**

You may have noticed in the transaction data that transactions are independent. The volume of transactions to/from each currency pair are equally likely (i.e., transactions from EUR to USD are as likely as transactions from USD to EUR). However, there are financial events that would alter this assumption. If a country defaults, their currency becomes much less stable and clients will try to get rid of it for something more stable. For the purposes of this stress test, assume that a country in the EU defaults. Examine the data set from the last time this occurred and see how it changes the parameters of your model. Note that transactions still occur in both directions, as some people will try to take advantage of the chaos and predict the recovery. How does the cash on hand differ compared to business as usual? Which values would you recommend to SafeBank and why?

### **Loss of counterparty**

GloboBank is SafeBank's counterparty. They are also a commercial entity. Like all commercial entities, they can go bankrupt. It happened to Lehman Brothers in 2008, and many banks were not prepared for it. When a counterparty files for bankruptcy, SafeBank loses the ability to swap with them. For this stress test, turn off the ability to swap with GloboBank. How does the cash on hand differ compared to business as usual? Which values would you recommend to SafeBank and why?

### **End of day settlement policy**

The scenarios listed above require the bank to reset their cash at the end of each day. The bank has always operated that way. However, it is not a strict requirement to do so. In this scenario, allow your simulation to run for 30 days. Instead of forcing the bank to reset at the end of each day, allow their balance to carry over to the next day. This will require choosing a settlement trigger point and a settlement quantity, similar to the swap trigger and swap quantity. What values maximize profit for the bank? How does this system design compare to the others in terms of revenue, cost, and profit?