Modeling Cross-Border Payments and Foreign Exchange Dynamics
– Correspondent Accounts Framework –

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Abstract

Most domestic payments are made by transfers of deposits, which are created by bank loans under the current debt money systems. Cross-border payments occur through the network of correspondent banks. Yet most existing models only abstract such system structure inappropriately. We introduce a generic framework of cross-border payments based on Accounting System Dynamics (ASD) modeling. We then perform preliminary optimization against reference mode of USD/TRY nominal spot rate during 2002-2018. Simulation results, though exploratory in nature, positively directs its future application to case studies. The new framework can be incorporated as a module of a large-scale ASD macroeconomic model with policy structure, non-linear feedbacks, and psychological variables. Its flexibility and inclusivity allow integration of flow of funds framework, balance of payments, and international investment position by considering financial flows such as FX-denominated loans, which are increasingly becoming one of key drivers of short-term volatility in developing markets after quantitative easing policy by major central banks.

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1 Need for Modeling Cross-Border Payments

The project's objective is to develop a comprehensive model that help us analyze recent events in the Turkish economy [5, 2019][1]. Towards this objective, we have set out a roadmap as follows:

Phase 1 A generic Accounting System Dynamics model of Turkish Macroeconomy is constructed by integrating overseas sector, and its model validations are examined. Meanwhile, we have collected Flow of Funds data since 2002, both in Turkish Lira (TL) and Foreign Exchange (FX), mainly utilizing DataTurkey. By using the generic model, optimization simulations are performed on population and labor force dynamics and real GDP and price against the reference mode. These partial optimizations are performed by using nominal aggregate demand data such as consumption, investment, government expenditures, exports and imports as exogenous data. Then, behavior reproduction tests are performed to confirm the validity of our ASD model construction.

Phase 2 One of the first challenges we faced was difficulty of integrating Flow of Funds data as inflows and outflows are not available in separate data format for financial transactions. Accordingly, we are obliged to reconstruct all inflows and outflows from financial transactions based on economic theories and hypotheses.

Phase 3 Aggregate demand and financial behaviors are optimized to simulate real and nominal GDP as well as money supply data. At this phase, our research focus is positioned on the recent disturbing economic events such as inflation, depreciation of Turkish Lira, and surge in unemployment rate.

Phase 4 Various scenario analyses for Turkish macroeconomic behaviors are pursued by running the constructed ASD model.

Purpose of Current Research

During the model development in phase 1, we have encountered difficulties to interpret and incorporate some of transaction items denominated in Foreign Exchange (FX) and Turkish Lira (TL) data provided by the Flow of Funds. Current framework of Correspondent Accounts is developed to solve such difficulties. Consequently the need for development is driven by the on-going Turkish macroeconomic model. Even so, the correspondent accounts model is developed as a generic model so that it can be incorporated into a large-scale ASD macroeconomic models to describe cross-border payments between any two countries.

[1]The research project of constructing ASD Macroeconomic Model of the Republic of Turkey has been supported by the TUBITAK grant (ref. #215K072) by the Turkish government. One of the authors of the current paper is its project member. This paper emerged from the contributions of the project members such as Prof. Seyid Fahri Mahmud, Social Sciences University of Ankara, Turkey, and Assist. Prof. Seyid Amjad Ali, the Department of CTIS, Bilkent University, Turkey.

2 Correspondent Deposit Accounts

We first consider cross-border payments to conceptualize a generic framework.

2.1 A Network of Correspondent Banks

As the need for payments by deposit transfer grew in commerce, a network of correspondent banks evolved over time. Each banking institution maintains deposit accounts through bilateral agreements as correspondent banks. At a macro level, this can be seen as a network of depository correspondent banks. Figure 1 illustrates such networks covering different currency regions today.

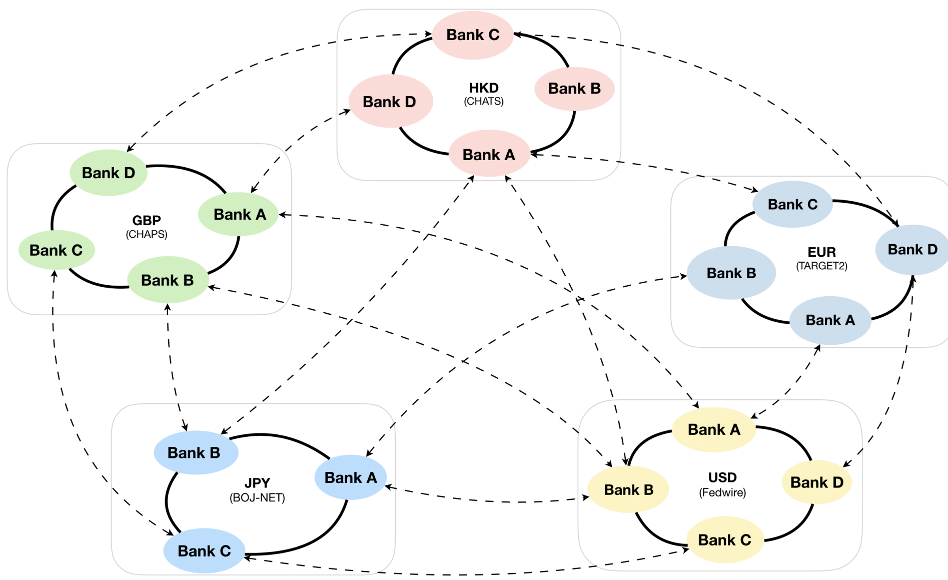

Figure 1: A Network of Depository Correspondent Banks

2.2 Opening Deposit Accounts

Correspondent Accounts Structure – Commercial Banks Layer

A balance in Nostro account is liquidity banks hold with another bank usually in foreign currencies. Ideally banks want to know their actual cash positions and base their funding requirements on their real positions rather than estimates. Normally, however, banks receive nostro account information at the end of the day via SWIFT (international payment messaging facility) statements from the correspondent banks. The information can be dispersed and needs to be aggregated overnight in many instances. Banks traditionally reconcile their nostro accounts using end-of-day reconciliation statements against their ledger balances at least one day after settlement (T+1). Conceptually aggregating the commercial banks operating mainly in each region, we arrive at two banking sectors. Multinational banks can be thought of as being divided into 'branches' in each currency region of its main profit-streams and business operation. Figure 2 illustrates an instance when two banks agree to mutually open and maintain deposit accounts as correspondent parties in foreign exchange services. As an example, let us consider banks in Japan and the United States. A left-hand side in the illustration shows transaction items of banking sector in Japan representing its balance sheet. For simplicity, we omit any investment portfolios and positions of the sector. A right-hand side illustrates that of the United States. Commercial banks hold deposits account at each central bank, and customer deposits denominated in home currency as their liabilities. In line with accepted notation of stock-flow diagrams in system dynamics modeling, rectangular shapes denote stock or level variables and arrows its flows (inflow or outflow). Direction of arrows conform with double-entry bookkeeping rules by following Accounting System Dynamics modeling [3, 2003].

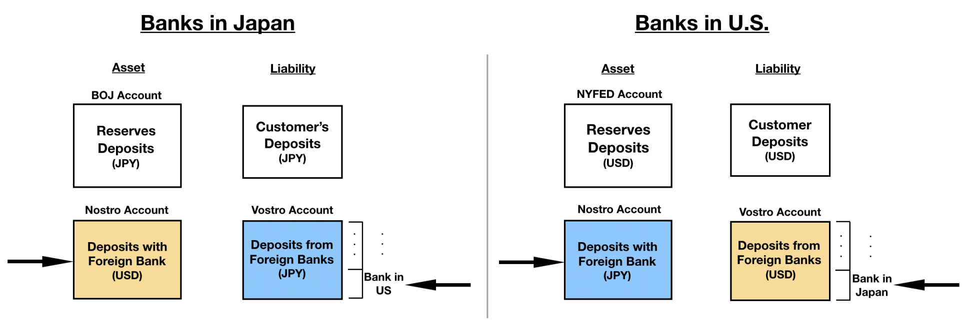

Figure 2: Commercial Banks mutually opening Deposit Accounts

As deposits accounts are opened and currencies are exchanged between banks for preparation, they make entries into each correspondent accounts. The term *Nostro* and *Vostro* referred to "ours" and "yours" respectively in Latin variations. Modern retail banking is said to have developed from 13-14th century Italy where both depositors and retail bankers maintained ledgers of their accounts. The ledger kept by the customer was called Nostro ledger, and the bank kept the corresponding Vostro ledger, and vice versa. Note that size of stock variables in Figure 2 does not indicate their relative amount of account balances. Customer's deposits (liability) are always much larger in comparison to reserve deposits and nostro deposits displayed here. Same blue and orange colors, however, indicate that balances of transaction items should be in equal when denominated in each original currency unit. Furthermore, banking sectors should have correspondent accounts in multiple currencies as implied by Figure 1. This feature is omitted in Figure 2 as we limit the boundary of analysis. However, readers can expand it step by step. This is the basic correspondent accounts framework between two economies at commercial banks layer.

Correspondent Accounts Structure – Central Banks Layer

Central banks have also developed similar practices of correspondent banking. In fact, the establishment of most central banks between the 19th-20th century, from payment system perspective, rendered correspondent accounts unnecessary for payments in the same currency unit. This was first enabled by paper-based processing and today in central clearing facilities and RTGS systems. Yet, as central banks are the sole issuers of currency in a single currency region in most nations today, they still need to rely on correspondents banks for international payment by its main customer such as the domestic government. Figure 3 illustrates an instance when two central banks agree to mutually open and maintain deposit accounts as correspondent parties in foreign exchange transactions. For simplicity, the figure omits any transaction items and portfolios of the central bank. Similarly the central bank in Japan holds FX deposits at the Federal

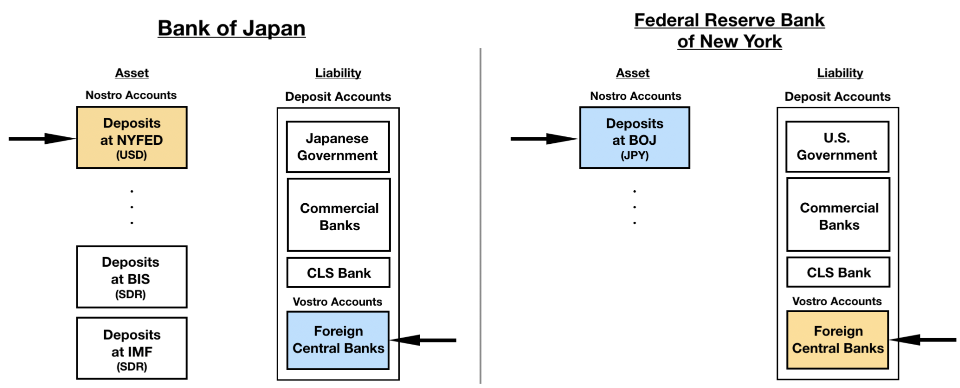

Figure 3: Central Banks mutually opening Deposit Accounts

Reserve Bank of New York, and vice versa. Note also the difference from the previous case of the commercial banks layer. Reserves accounts of commercial banks are liabilities of central banks. Among the reserves account, CLS bank provides payment-versus-payment (PVP) settlement facility for multi-currency transactions, mainly between financial institutions. CLS (Continuous Linked Settlement) service has started operating since October 2002, and it has expanded into18 currencies including JPY and USD. CLS bank enables PVP by maintaining its own deposits account at each central bank as shown in Figure 3. Most international banks are its core settlement members, and other financial institutions as well as third party customers use CLS. However, CLS Bank is a limited purpose bank, and its account balances become zero at the end of each operating days. Furthermore, cross-border payments through correspondent accounts are still fully used today in international trades. Turkish Lira is out of coverage in CLS facility as of 2018. Accordingly the correspondent accounts framework at the central bank layer provides a role in our analysis.

2.3 Imports with Foreign Currency & FX Settlements

Let us next examine how payments in international trades can be described based on the framework. We start by considering imports by producers in Japan (home country) with foreign currency. That means producers in the US (foreign country) are exporting in their domestic currency USD. For simplicity, we do not consider letter of credit here. Then, for our purposes, stylized international trades and foreign exchange would be simplified into following transaction steps:

Step 1 Exporter in the U.S. issue bill of exchange to the importer or banks in Japan as specified. Exporter's banks in US transfer the bill to its correspondent bank in Japan (or may purchase it and pay the discounted amount to exporter at this step).

Step 2 Importer is notified by its bank and pay the bill in exchange for the shipping documents including bill of landing.

Step 3 Bank in Japan must transfer the amount in USD to the exporters bank. The bank in Japan obtain USD from interbank FX market on behalf of the importer into its Nostro USD deposit account with its depository correspondent banks.

Step 4 Importer's bank in Japan sends USD from its Nostro account to Exporter's account at the destination bank in US. Corresponding amounts are debited from Importer's account in JPY converted at the Telegraphic Transfer Selling (TTS) rate applied.

We can reclassify these steps into two categories of cross-border payments: payments between Importer-Exporters accounts, and payments between correspondent accounts of banks involved (interbank settlements & nostro reconciliation). Figure 4 summarizes imports by domestic producers with foreign currency and

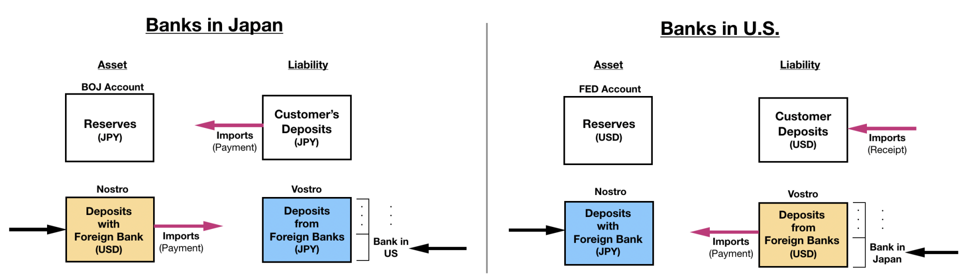

Figure 4: Domestic Imports and Foreign Exchange Settlement

foreign exchange transaction. Pink arrows indicate changes in account balance caused by payments between Importer-Exporters whereas black arrows indicate changes caused by buying and selling of the currency pairs at interbank FX market, and payments to exporter's account at the destination bank by the

Japanese bank through its nostro USD account. It should be noted here that we are assuming the foreign currency for import payment (USD in the above case) was obtained against a commercial bank in the U.S through interbank FX market. That is why nostro-vostro account balances in both sides of banking sector are increased as shown by black arrows. However, the resulting changes in nostro and vostro accounts differ depending on currency region the transaction counter-party is located. By considering the counter-party in the interbank FX market, it turns out that we must consider three different cases for any specific currency pair under study. For instance, if a bank in Japan had bought USD from banks in third nation other than Japan or the U.S, say in the Euro area, vostro USD balance of European banks is decreased in stead of increasing nostro JPY balance of banks in the US. Under such assumption, nostro JPY balance of European Bank is increased in a similar way. Another case is where the importer's bank in Japan obtained USD against another bank from Japan through FX market. In such cases, nostro USD balance of banks in Japan, thus corresponding Vostro balance of US banks, will ultimately decrease as a result of import payments in USD. The example in the above Figure 4 reflects one of these three possible cases described here.

Summary of Changes in Account Balances

Vostro JPY account of banks in Japan (import-side), thus nostro JPY account of foreign banks (export-side), increases as a result of imports by domestic producers with foreign currency. This is due to the specific assumption that foreign currency for import payment was obtained by banks in the exporting side through FX market.

2.4 Exports with Domestic Currency & FX Settlements

Let us next analyze the opposite case of the previous case; that is, domestic producers (in Japan) export with domestic currency (JPY). Similarly a stylized international trade and foreign exchange are simplified into the following steps:

Step 1 An exporter in Japan issues a bill of exchange to the importer or banks in the US as specified. The exporter's bank in Japan transfer the bill to its correspondent bank in the US (or may purchase it and pay the discounted amount to exporter at this step - discounting bills).

Step 2 The Importer in the US is notified by its bank and pay the bill in exchange for the shipping documents (assuming documents against payment terms).

Step 3 The bank in the US must transfer JPY to the exporter's account at a destination bank in Japan. The exporter's bank in the US obtain JPY from FX market into its Nostro JPY account with its depository correspondent banks in Japan.

Step 4 The importer's bank in the US sends JPY from its Nostro account to exporter's account at the destination bank in Japan. Corresponding amounts are also debited from the importer's account in USD converted at the Telegraphic Transfer Selling (TTS) rate applied.

Figure 5 summarizes exports by domestic producers with domestic currency and foreign exchange transaction involved.

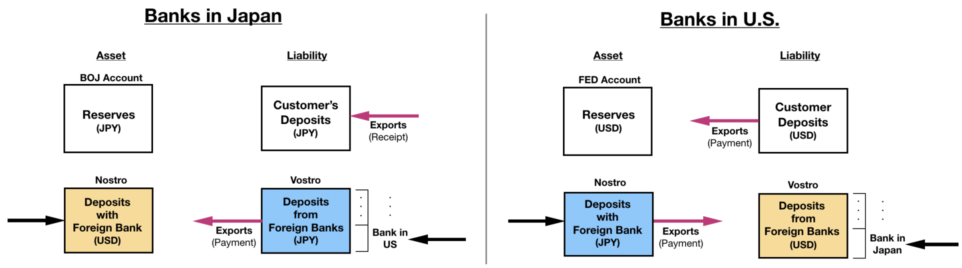

Figure 5: Domestic Exports and Foreign Exchange Settlement

The resulting changes in nostro and vostro accounts differ depending on currency region the transaction counter-party in interbank FX market is located. As in the case of domestic imports, the above case shown in Figure 5 consider one of the three possible scenarios.

Summary of Changes in Account Balances

Nostro USD account of banks in Japan (export-side), thus vostro USD account of foreign banks (import-side), increases as a result of exports by domestic producers with domestic currency. This is due to the specific assumption that domestic currency for export payment by the importer in US was obtained by banks in the exporting-side (Japan) in the FX market.

3 Modeling Cross-Border Payments

By applying the new framework conceptualized in the previous section 2, we have developed a simplified and generic model to capture behaviors of foreign exchange rate.

3.1 Balance Sheets of Domestic & Overseas Sectors

A total of seven sectors are considered in our analysis: four from domestic economy and three sectors from the overseas. The term *overseas* in the current research is used rather ambiguously, which can be interpreted as a specific economy with its own currency region, or the rest of the world that uses a specific currency in international trades. Seven macroeconomic sectors are incorporated under the current model of two economies as follows.

1. Central Bank in Figure 6
2. Central Bank Overseas in Figure 7
3. Banks in Figure 8
4. Banks Overseas in Figure 9
5. Government in Figure 10
6. Producers in Figure 11
7. Producers Overseas in Figure 12

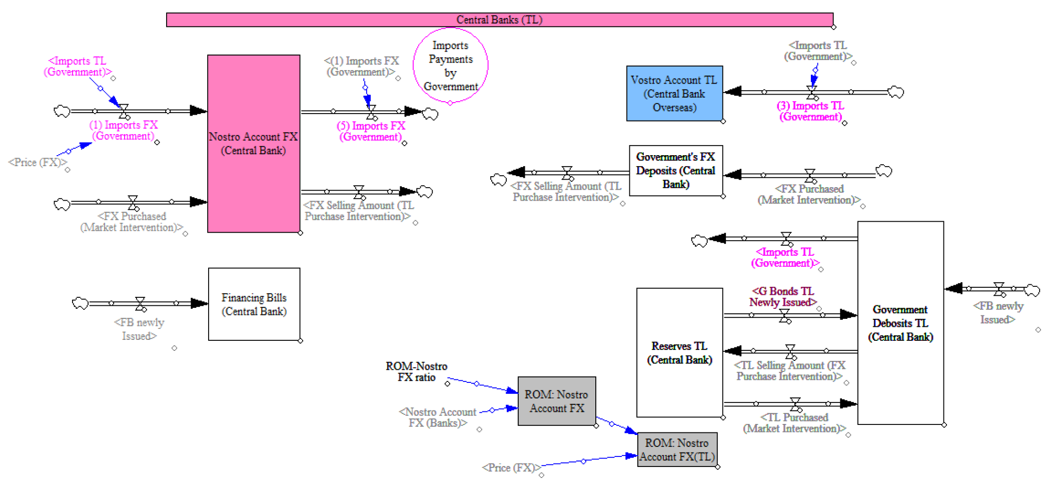

Figure 6: Central Bank

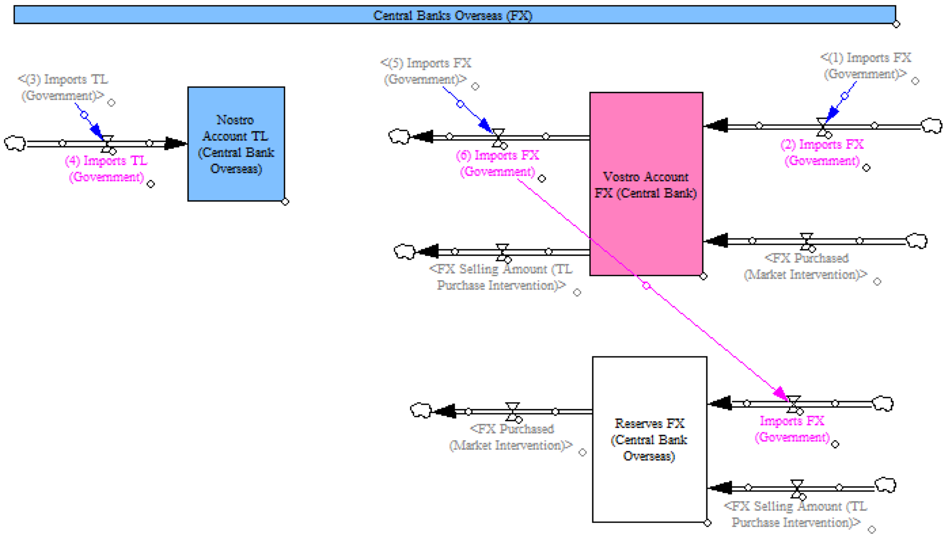

Figure 7: Central Bank Overseas

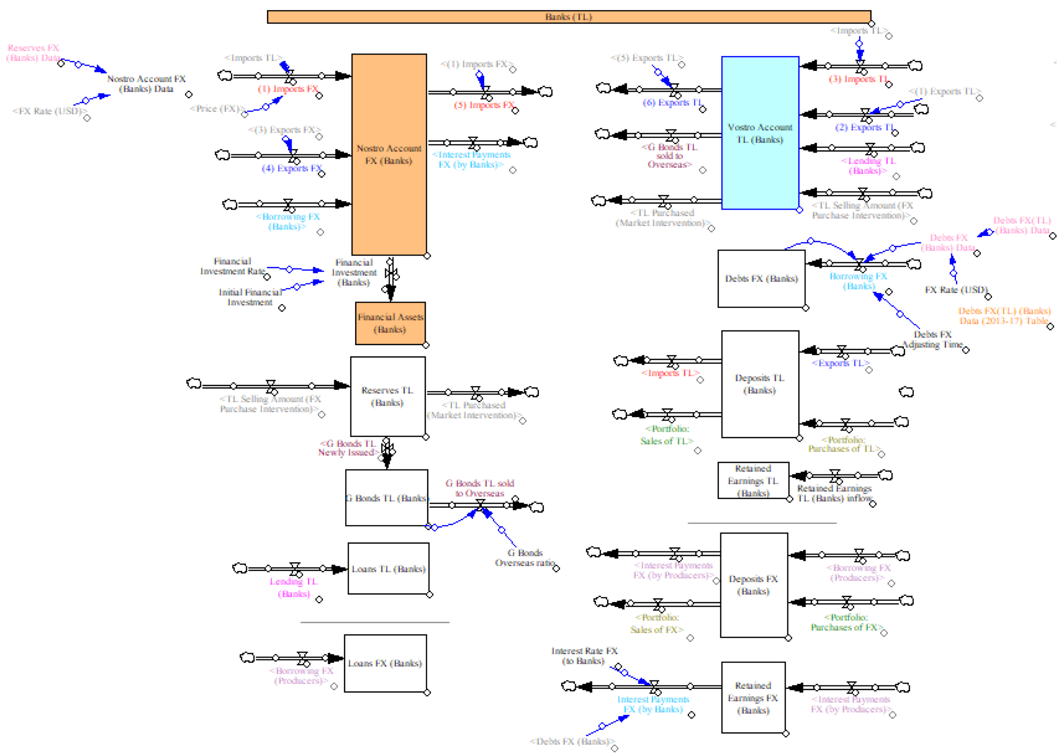

Figure 8: Banks

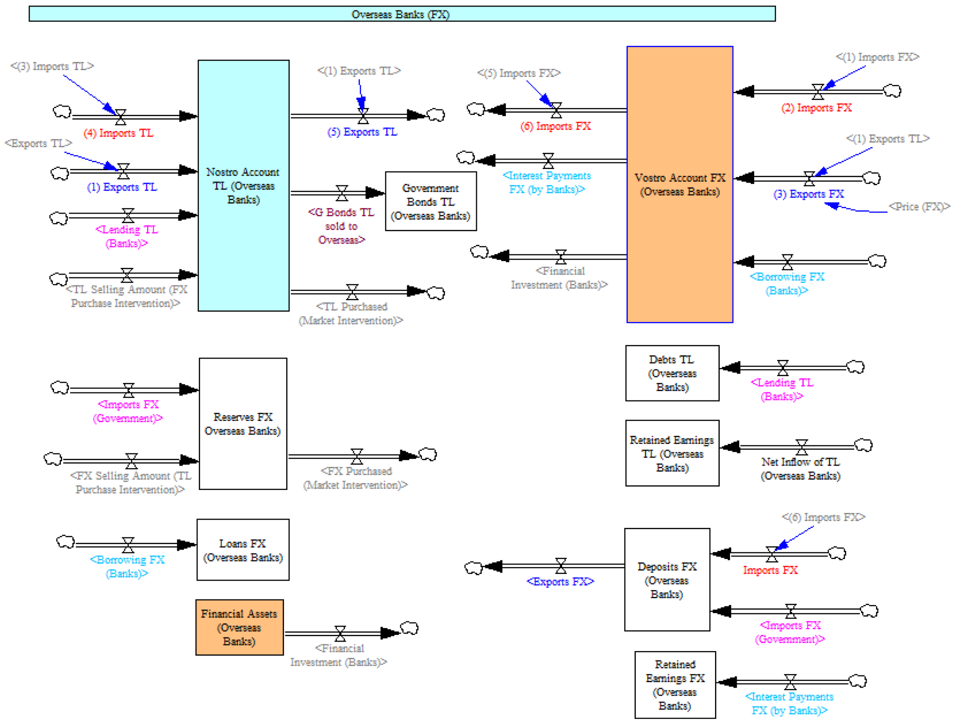

Figure 9: Banks Overseas

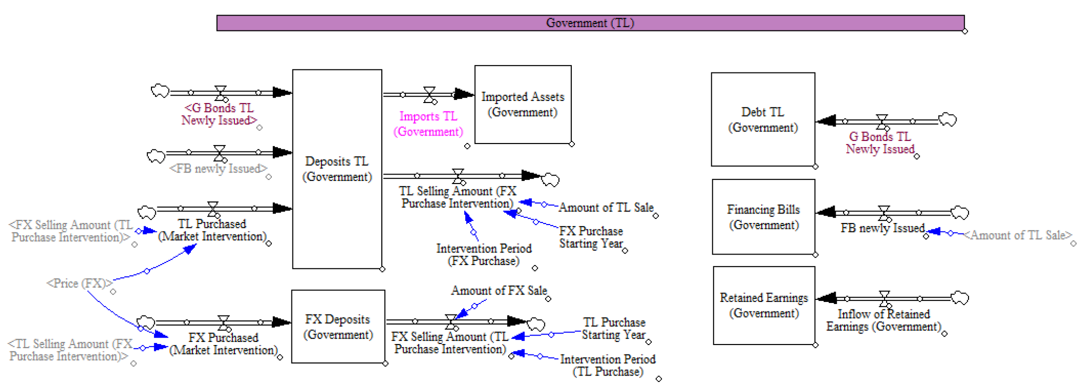

Figure 10: Government

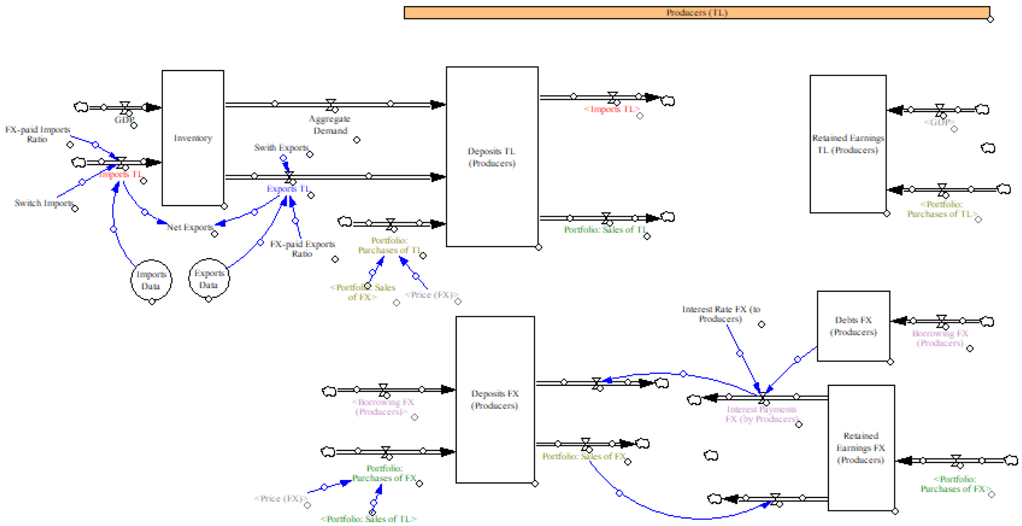

Figure 11: Producers

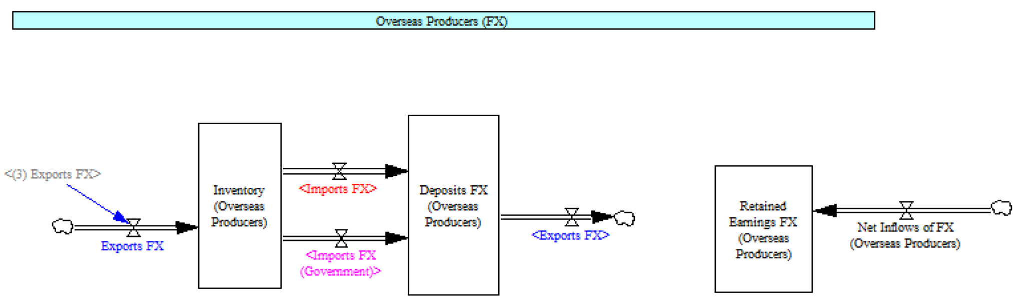

Figure 12: Producers Overseas

4 Cross-Border Payments - A Case of Turkey

We have taken USD/TRY nominal spot rate since 2002-2018 as a reference case for the preliminary application of the proposed modeling framework.

4.1 Exchange Rate Determination

Turkey is assumed to be the home country, and its currency unit is denominated in TL. Overseas sector is assumed to be the United States as we consider historical behavior of nominal rate between USD/TRY. We also like to note that all structural simplifications made in the previous section are similarly inherited into the simulation model.

Figure 13 shows a part of our model that determines foreign exchange rate. Exchange rate is determined by the supply and demand for foreign currency, which are determined primarily by imports and exports between two economies.

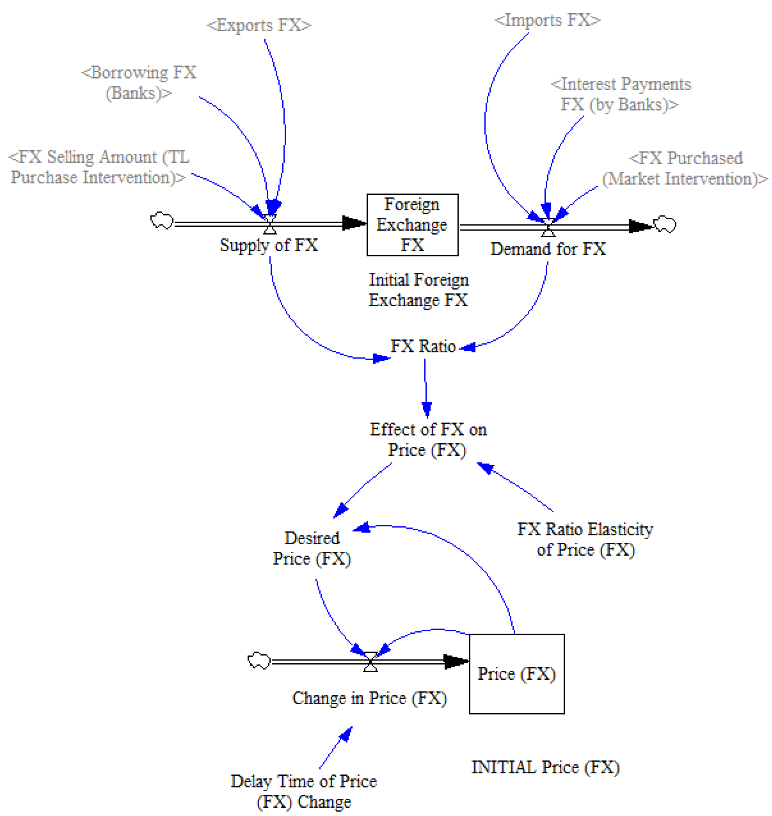

Figure 13: Determination of Foreign Exchange Rate

4.2 Balance Sheets Check

A left-hand diagram in Figure 14 shows balance sheet checks of banks, producers and government. Due to the accumulated stock errors of annual conversion of FX unit (USD) into domestic unit (TL) for banks (domestic and overseasI, their balance sheet checks fail as lines 1 and 2 in the diagram indicate. However, if

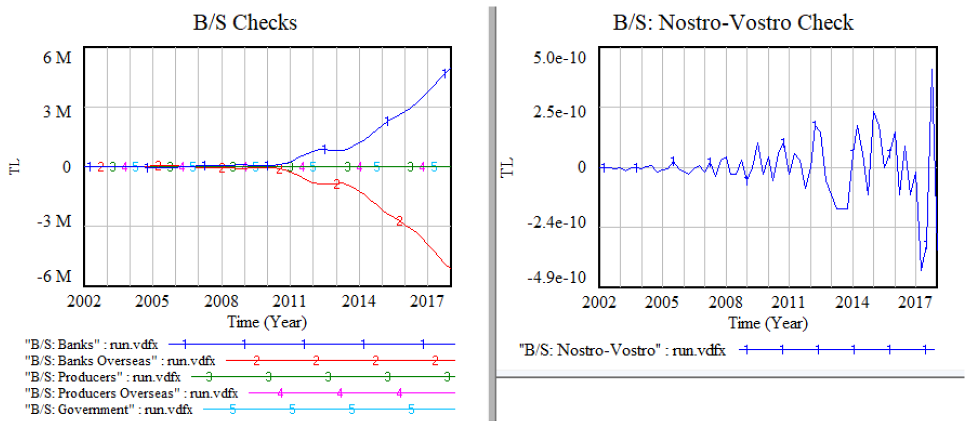

Figure 14: Balance Sheets Check

we consider the consolidated balance sheet of correspondent accounts by banks; that is, parts of lines 1 and 2, its balance sheet check is cleared as illustrated by the right-hand diagram of Figure 14.

5 Optimization of Turkish FX Payments

As a preliminary application of the present cross-border payments model, we applied it to the case of the Republic of Turkey. The data we used to run this model consist mainly of the following three time-series adopted from our ongoing project of Turkish case briefly explained in section 1; that is, (1) exports and imports, (2) FX Debts of Turkish banks. Those data are the exogenous inputs to foreign exchange rate structure shown in Figure 13, and what constitutes the Balance of Payments in the present model. Specifically, imports-exports data are obtained as aggregate nation-level data from GDP, and FX Debts from Flow of Funds data in Turkey.

Obtaining Net FX Borrowings of Turkish Banks

Imports-exports data in TL unit are converted to FX data with USD unit by using the nominal rate during the same period. On the other hand, stock data of FX Debts by Turkish banks are converted into net flow data of Borrowing FX as illustrated in Figure 15. In the left-hand diagram, line 2 (red) indicates the real historical data of FX debts by banks, line 1 is its adjusted data of FX debts.

Right-hand diagram shows the calculated values for net flow of FX Debts data called Borrowing FX (Banks). In other words line 1 in the left hand diagram is produced by this net inflow.

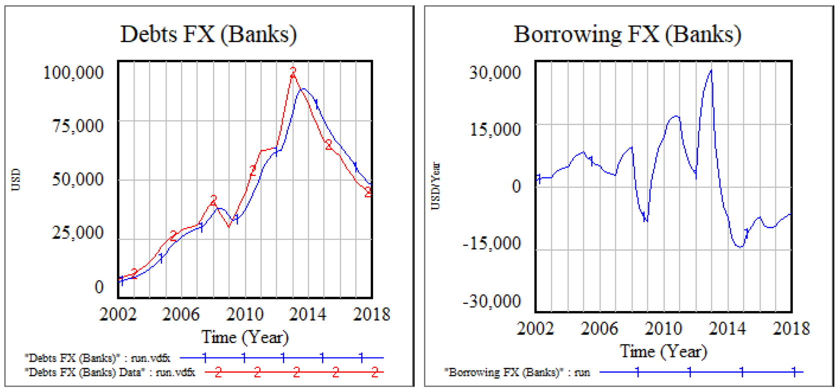

Figure 15: FX-denominated Debts and Borrowings (inflows)

Optimization: USD/TRY between 2002-2018

It turned out that the simple model shown in Figure 13 captures dynamics underlying the exchange rate, as demonstrated by the following optimization. Our optimization is performed by the five parameters as indicated in Figure 16. With these simple rearrangement of trade and capital flow data, our model

```
1 <= "INITIAL Price (FX)" = 1.59104  <= 3
0 <= "FX Ratio Elasticity of Price (FX)" = 11.2838  <= 20
0 <= "FX-paid Exports Ratio" = 0.0205434  <= 0.3
0 <= "FX-paid Imports Ratio" = 0.140641  <= 0.4
1 <= "Delay Time of Price (FX) Change" = 8.06537  <= 15
```

Figure 16: Parameter Values from Optimization

turned out to be able to simulate Turkish foreign exchange rate quite reasonably as demonstrated in Figure 17 below.

Some parameters may need further explanation. First, FX Ratio Elasticity of Price (FX) provides a per cent (%) change in Price (FX) caused by a per cent (%) change in FX Ratio, which is defined as the ratio of foreign exchange supply over its demand. The elasticity thus defined has a robust nature of a uniform elasticity over its entire range as demonstrated in Chapter 2 of the book [4, 2013]. Due to this nature, it has been uniformly used in models presented in the book as a key parameter of price adjustment mechanism in all types of prices. Given these data and model structure, this FX ratio elasticity of price (FX) turned out to be vey elastic in Turkey; that is, it is 11.28. This implies

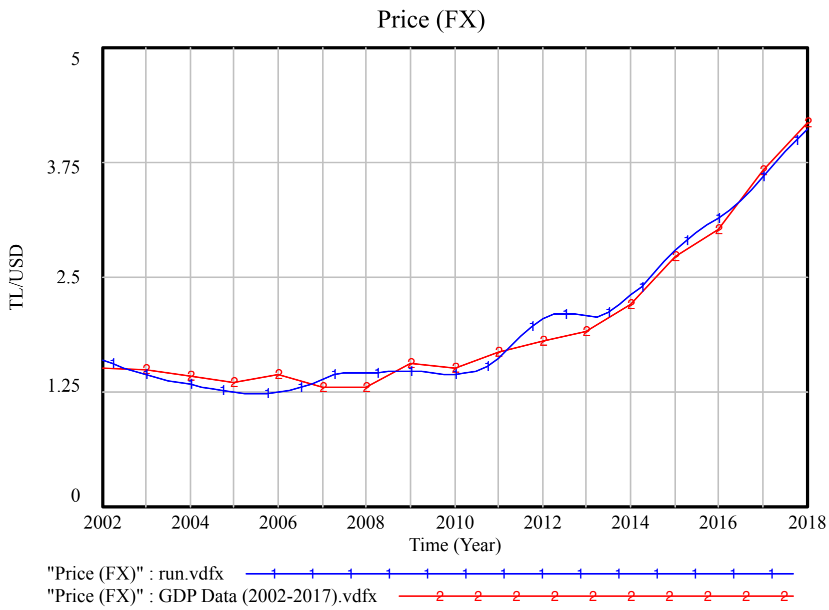

Figure 17: Nominal Exchange Rate of USD/TRY between 2002-2018

that if supply-demand ratio of foreign exchange fluctuates by 10%, it causes exchange rate to fluctuate by more than 110 %. In other words, Turkish foreign exchange rate against USD is shown to be vulnerable to a small changes in quantity of foreign currency; that is, tighter FX triggers a large appreciation of FX.

Furthermore, the simulation indicated that only 2% of exports are paid with foreign currency, while 14% of imports are paid with foreign currency. This implies that Turkish economy receives less foreign currency while it has to prepare a large amount of foreign currency for import payments. This seems to suggest that there has been a higher demand for FX from import payments, which tends to put downward pressure on TL towards persistent depreciation. More granular data on cross-border payments that may justify the above interpretation are not available in our hands. Hence our discussion here is nothing but working hypothesis generated from the simulation.

In summary the obtained values from parameter optimization give us insights into the exchange rate determination by a simple model structure and a small number of parameters such as FX ratio elasticity and FX-paid ratios. In this sense, the modeling framework could provide a novel approach for the analysis of exchange rate determination considering the limited availability of related data. Published data in balance of payments and trade statistics is modified through nominal conversion during compilation. The new framework calls for the original first-hand data denominated in each currencies for more rigorous analysis.

6 Behavior Reproduction Test

6.1 Testing Measures

So far we have discussed optimization simulation of Turkish foreign exchange rate. How can we validate these results obtained in replication of the reference behavior? As behavior reproduction tests, we follow the measures proposed in Chapter 21 by John Sterman [2, 2000]: *Truth and Beauty; Validation and Model Testing*. The most widely reported measure of fit is R^2 (R Square); that is, coefficient of determination, which is obtained as the square of the correlation coefficient r. R^2 and r are defined as follows.

$$R^2 = r^2; r = \frac{1}{n} \sum \frac{(X_d - \bar{X}_d)}{s_d} \frac{(X_m - \bar{X}_m)}{s_m}, \tag{1}$$

where X_d and X_m stand for data and model values, and $\bar{X}_d$ and $\bar{X}_m$ stand for their mean values, while s_d and s_m represents standard deviation of data and model, respectively.

According to this measure, if the model exactly replicates the actual data, we have $R^2 = 1$; if the model output is constant, we have $R^2 = 0$. In other words, if R^2 gets closer to one, we could conclude the model fits quite well to the data. Sterman argues, however, that "R^2, though it is widely reported and your audience may expect it, is actually not very useful [2, p.874]. Therefore, we should also use this R^2 measure with caution.

Better measures of our optimization tests are, following Sterman, MSE (Mean Square Error), which is defined as

$$\text{MSE} = \frac{1}{n} \sum (X - X_d)^2. \tag{2}$$

MSE thus defined weights large errors between the simulation and actual data. Moreover, this measure can be used to apply the so-called Theil Inequality Statistics. That is to say, MSE can be decomposed into three components: bias, unequal variation and unequal covariation.

> Bias arises when the model output and data have different means. Unequal variation indicates that the variances of the two series differ. Unequal covariance means the model and data are imperfectly correlated, that is, they differ point by point. Dividing each component by the MSE gives the fraction of the MSE due to bias (U^m), the fraction of the MSE due to unequal variation (U^s), and the fraction of the MSE due to unequal covariation (U^c). Since $U^m + U^s + U^c = 1$, the inequality statistics provide an easily interpreted breakdown of the sources of error [2, p.875].

How can we use this breakdown measures of MSE, then, to evaluate our simulation results? Sterman [2, 2000] suggests in chapter 21 as follows. A large bias (U^m) reveals a *systematic* error due to errors in parameter estimates. A large unequal variance (U^s) may also be s*ystematic* because the trend in the two variables is different, and direct attention to the assumptions of the model is needed. In short, large errors of (U^m) and (U^s) require some revision of model structures or model assumptions.

Compared with these systematic errors, a large unequal covariation, capturing the mean and trends in the data well, indicates "the presence of noise or cyclical modes in the data series not captured by the model." Accordingly, it is *unsystematic* and "a model should not be faulted for failing to match the random component of the data (p.877)."

6.2 Model Testing for Price(FX)

With these measures in mind, we are now in a position to test our simulation results. Figure 18 reports our optimization results on foreign exchange rate.

Componen	Price (FX)/1
Source	GDP Data (2002-2017)
RSquare	0.980064
DW	1.2888
Autocor1	0.332262
Autocor2	-0.143049
Autocor3	-0.188142
Autocor4	-0.00204019
RMSE	0.119985
Um	0.0111635
Us	0.00344561
Uc	0.985391
MAE	0.108226
MAPE	6.29952
MAEoM	5.41925

Figure 18: Payoff Report on Price(FX)

Concerning the Theil inequality statistics, R^2 value is 0.98, that is, very close to one, demonstrating very nice fitting with data. Errors of U^m for foreign exchange rate is 0.011 The small bias (U^m) reveals a negligible *systematic* error due to errors in parameter estimates. Errors of (U^s) is 0.003. The small unequal variance (U^s) may indicate that it is not *systematic* because the trend in the two variables is not different. Accordingly, no direct attention to the assumptions of the model is needed. In short, small errors of (U^m) and (U^s) suggest no "revision of model structures or model assumptions".

Meanwhile, U^c is 0.985. This large unequal covariation captures "the mean and trends in the data well", and indicates only "the presence of noise or cyclical modes in the data series not captured by the model." Therefore, the errors can be said to be *unsystematic* and "a model should not be faulted for failing to match the random component of the data (p.877)."

7 FX Market Intervention - Policy Structure

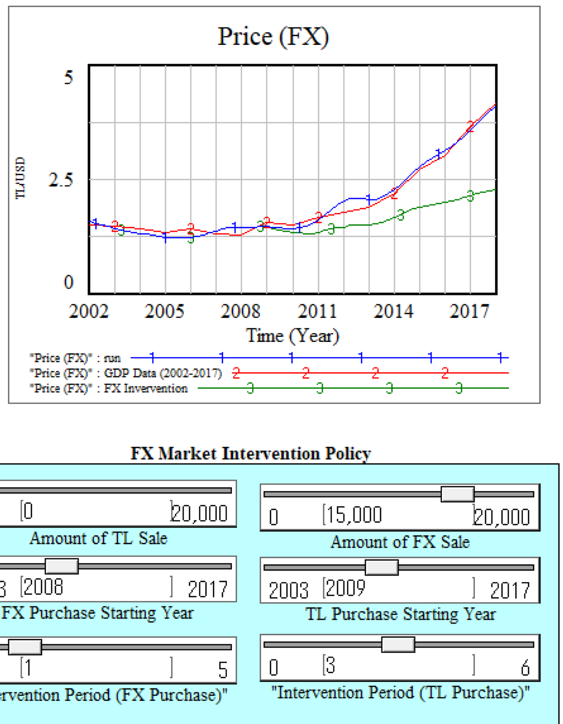

Figure 19: FX Market Intervention Policy & Simulation Panel

As an another simulation experiment, a hypothetical market intervention scenario is explored. Specifically FX-selling intervention is introduced for 3 years for the amount of \$15,000 billion starting in the year 2009 as a response to the Lehman shock, without changing any other model parameters. Under this *ceteris paribus* case, FX rate is maintained under 2.5TL per USD as shown by line 3 in Figure 19. The appreciation of TL following this policy, however, would have in turn affected the amount of imports and exports, and other variables. Such FX-selling interventions require a large amount of foreign currency reserves. Yet the present model lacks such feedback effects and funding caps.

Therefore, the current model has to introduce additional structure to improve the realistic intervention experiment. Our remark here is just to illustrate that the new framework is flexible enough to investigate policy factors underlying the FX market.

8 Reserve Options Mechanism: Next Step

As briefly explained in Section 1, we have encountered a new policy arrangement called Reserve Options Mechanism (ROM) during our Turkish macroeconomic model development, which was introduced by the Central Bank of the Republic of Turkey (CBRT) in November 2010 [1, 2013]. Since then Turkish banks has an option to maintain reserves with gold, USD, and EUR in addition to its domestic currency. This might have had significant effects on FX market dynamics but also on inflation and other macroeconomic variables through exchange-rate pass-throughs. How to interpret FX-denominated data in the Flow of Funds and to incorporate such policy structure has become another challenge in our project. Given the historical data such as imports, exports and FX debts by banks, Nostro FX balances of Turkish banking sector can be estimated by applying the correspondent accounts framework introduced in the current research. We can successfully capture a peculiar behavior of FX reserves by the CBRT (line 2 in red) as ROM reserves (line 1 in blue) during the period between 2002 and 2013 as shown in Figure 20. Accordingly, we are now in a process of incorporating the framework into our macroeconomic model to provide structural analysis of ROM and its role in the Turkish economy.

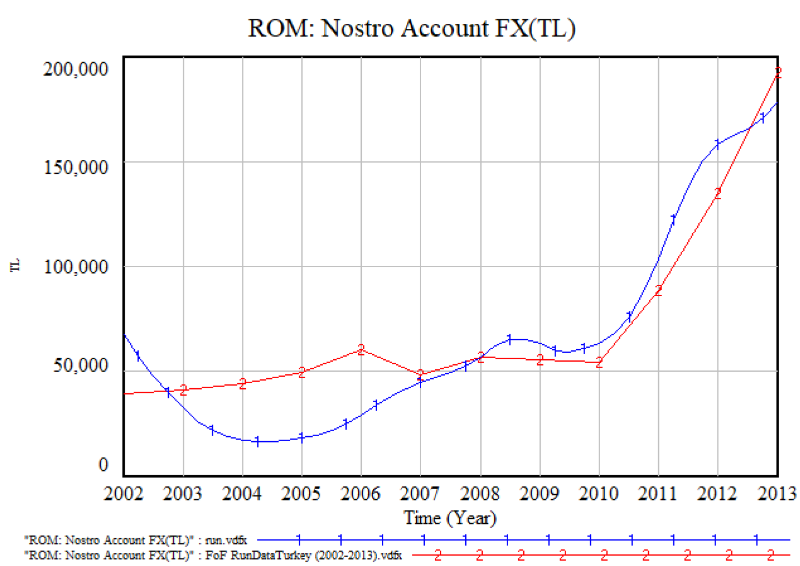

Figure 20: Turkish Banks increasing FX through Reserves Option Mechanism

Conclusion

We have introduced a correspondent accounts framework in order to capture cross-border payments based on Accounting System Dynamics (ASD) modeling approach. Firstly nostro-vostro accounts are conceptualized as mutual depository accounts of banking sector in each economy. Correspondent accounts are separately structured at central banks and commercial banks layer to reflect cross-currency settlement systems in the model. We then performed optimization against the reference mode of USD/TRY nominal spot rate between 2002-2018. Preliminary simulation, though exploratory in nature, positively directs its future application to case analysis. The new framework can be incorporated into a large-scale ASD model to test existing theories of foreign exchange dynamics, or for extension of them for applied case studies. It is inclusive in that it can handle financial flows such as FX-denominated loans and interventions by central banks, allowing the integration of flow of funds framework, balance of payments, international investment position within the proposed framework.

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