Constructing ASD Macroeconomic Model of the Republic of Turkey (2002-2017)

– Integrated Analysis of GDP and Flow of Funds (Phase 1) –

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Abstract

We are currently developing a Turkish ASD macroeconomic model that incorporates analytical methods of National Account of GDP by the government and Flow of Funds by the central bank, and enables to analyze endogenous money creation that affects behaviors of real and financial market economy.

The purpose of this paper is to report the first phase of our research; that is, to construct a comprehensive ASD model that reflects the transactions of real and financial economic sectors by importing the Flow of Funds Accounts data consisting of TL and FX data developed by DataTurkey

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group. At this phase, we have estimated various parameter values that determine population dynamics and real GDP growth as well as price level as GDP deflator by using population data such as fertility and population cohorts, and macroeconomic aggregate demand data such as consumption, investment, government expenditures, exports and imports as the model data.

Then, behavior reproduction tests are performed by Theil statistics for three partial optimization simulations; that is, population, labor force and real GDP-price. Based on these simulation results, some findings on the Turkish macroeconomy are discussed such as production capacity and causes of inflation.

1 Introduction

Standard Mainstream Model

The general equilibrium framework of the of Standard Mainstream Model (SMM) does not adequately model the financial-real sector interactions due to reasons ranging from analytical convenience to their axiomatic foundations. These limitations have caused significant erosion of the explanatory power of the SMM in explaining the factors leading to and, consequently, in anticipating the financial crisis in the United States in 2008. Furthermore, it also led to the SMM' s inability of developing effective central bank policies to deal with the great recession that followed the crisis. For the same reason, the SMM could not explain important anomalies and puzzles, such as the decline and instability of the velocity of money or the lost decades of Japan and ineffectiveness of quantitative easing (QE) policies. At the core of the shortcomings of the SMM is its inability to introduce any role of money and the financial sector. Firstly, it portrays banks as a simple, neutral channel reallocating savings to investments under the Intermediation Loanable Funds (ILF) theory. However, in the real world, the modern banking system functions quite differently. It is now well documented that banks create new money in the act of lending. This is done by matching both loan and deposit entries in the name of the same customer simultaneously as 'financing through lending' (FMC) theory suggests. The only constraint the banks face in their ability to create new money through credit extension concerns their expectations of profitability and solvency. Secondly, money is strictly linked to the transactions in the real side of the economy in SMM framework. In the real world, significant flows of bank created credit (debt money) go to the transactions in the financial sector (such as mortgage loans). Therefore, any growth in debt in excess of the size of the economy is not conceivable in the mainstream models. In short, some of the main limitations of family of Dynamic Stochastic General Equilibrium (DSGE) models that have been developed using SMM structure are as follows [1, 2017]:

1) Banks are taken as mere financial intermediaries between savers and investors (ILF):
   However, many reports of Central Banks observe that banks create new

money endogenously: money is credit. Money created by banks not only finances output (real economy) but also financial and real estate transactions, which do not contribute to GDP directly.

2) Real world aggregate private debt has no macroeconomic implication. Only distribution of debt matters:
Yet, under the endogenous money perspective, aggregate private debt has macroeconomic implications, growing aggregate debt (money) is a source of economic growth but it can also contribute to financial fragility (Distribution of debt to productive and non-productive channels matters).

3) Modelling is based on micro-foundations and assumes rational behavior of agents, therefore the model cannot generate instability. Instability is caused by exogenous shocks only:
It has been shown that debt- based system is inherently unstable with cycles of booms and busts. Many shocks are endogenous in the system.

4) Markets are efficient:
With imperfect and asymmetric information, markets are mostly inefficient.

5) Money issuance by the central bank (e.g. QE) over and above the real growth of output will create inflation:
However, QE policies have proven to be ineffective in leading to inflation, particularly during post-crisis deleveraging process.

Macro-econometric model

Economic forecasting and econometric models, structural and nonstructural, have been widely used since the 1970s. Structural models are built using the fundamental principles of economic theory, often at the expense of the model' s ability to predict key macroeconomic variables like GDP, prices, or employment. However, these models have also failed in predicting the recent crisis. The failure of these models have also been partly attributed to the their failure to incorporate financial sector and/or effectively incorporating the worldwide financial and trade linkages. On the other hand, nonstructural models are primarily statistical time-series models; that is, they represent simple correlations of historical data. They may incorporate very little economic structure, and this fact gives them enough flexibility to capture the force of history in the forecasts they generate. However, lack of realistic economic structure makes them less useful in terms of interpreting the forecast.

Why ASD model?

To overcome these limitations discussed above, we have employed an alternative mocroeconomic model for our research on Turkish macroeconomic behaviors; that is, Accounting System Dynamics (ASD) model. It has been shown that

ASD model can not only integrate real and financial sectors more effectively but also elucidate the creation process of endogenous money by the banking sector. This paper is based on our ongoing research project funded by TUBITAK. The project's ultimate goal is to develop a comprehensive macroeconomic model of Turkish economy based on ASD methodology. Our roadmap of this research is as follows:

Phase 1 A generic ASD 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, and imported them into our model. By using the generic model, partial optimization simulations are performed on population and labor force dynamics and real GDP and price. These partial optimizations are performed by using nominal aggregate demand data such as consumption, investment, government expenditures, exports and imports as exogenous model data. Then, their statistics are performed as behavior reproduction tests to confirm that our ASD model is not faulted.

Phase 2 True difficulty of integrating Flow of Funds data is non-existence of inflow and outflow data for financial transactions are made available. Accordingly, we are obliged to reconstruct all financial transaction inflows and outflows by our research hypotheses based on economic reasoning and rationale.

Phase 3 Aggregate demand and financial behaviors are simulated to fit real and nominal GDP as well as money supply data. At this phase, our focus is positioned on the recent disturbing economic behaviors such as inflation, devaluation of Turkish Lira, high unemployment rate, etc.

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

2 ASD Macroeconomic Model

The modeling method of Accounting System Dynamics is presented by Yamaguchi [4, 2003]. It is called the Principle of Accounting System Dynamics (ASD). Based on this ASD modeling method, a series of macroeconomic model are constructed in the book [5, 2013]. Generic model of the ASD macroeconomic model presented in chapter 9 of the book is used for constructing our Turkish macroeconomic model. Its basic framework is revisited from the chapter as in Figure 1. It shows that the economy consists of five macroeconomic sectors: Producers, Consumers (Households here), Government, Banks and Central Bank.

For the convenience to the reader, let us briefly revisit major transactions among these five sectors

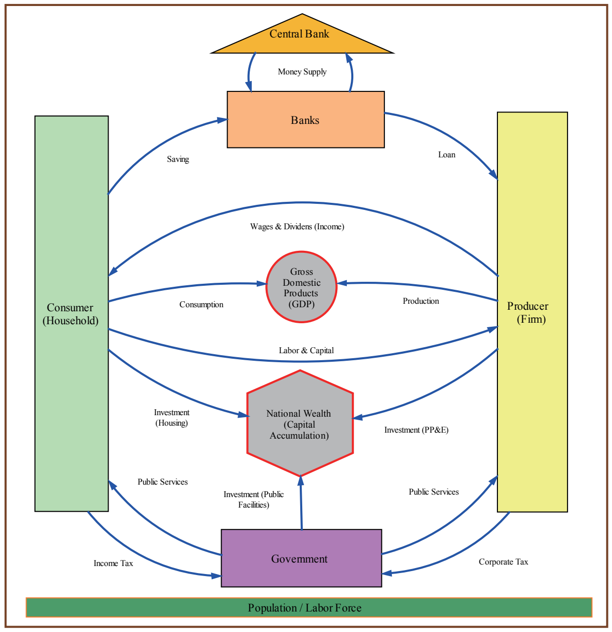

Figure 1: Macroeconomic Overview of Chapter 9

Producers

Major transactions of producers are summarized as follows:

- Producers import goods from overseas and export them to overseas.
- Out of the GDP revenues, producers pay excise tax, deduct the amount of depreciation, and pay wages to workers (consumers) and interests to the banks. The remaining revenues become profits before tax.
- They pay corporate tax to the government out of the profits before tax.
- The remaining profits after tax are paid to the owners (i.e., consumers) as dividends.
- Producers are thus constantly in a state of cash flow deficits. In order to continue new investments, they have to borrow money from banks and pay interest to the banks.

Consumers (Households)

Major transactions of consumers are summarized as follows:

- Consumers receive wages and dividends from producers.

- Financial assets of consumers consist of bank deposits and government securities, against which they receive financial income of interests from banks and government.
- In addition to the income such as wages, interests, and dividends, consumers receive cash whenever previous securities are partly redeemed annually by the government.
- Out of these cash income as a whole, consumers pay income taxes, and the remaining income becomes their disposal income.
- Out of their disposal income, they spend on consumption. The remaining amount are either spent to purchase government securities or saved.

Government

Major transactions of the government are are summarized as follows:

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers.
- Government spending consists of government expenditures and payments to the consumers for its partial debt redemption and interests against its securities.
- Government expenditures are assumed to be endogenously determined by either the growth-dependent expenditures or tax revenue-dependent expenditures.
- If spending exceeds tax revenues, government has to borrow cash from consumers by newly issuing government securities.

Banks

Major transactions of banks are summarized as follows:

- Banks receive deposits from consumers, against which they pay interests.
- They are obliged to deposit a portion of the deposits as the required reserves with the central bank.
- Out of the remaining deposits loans are made to producers and banks receive interests for which a prime rate is applied.
- Their retained earnings thus become interest receipts from producers less interest payment to consumers. Positive earning will be distributed among bank workers as consumers.

Central Bank

Major transactions of the central bank are summarized as follows:

- The central bank issues currencies against the gold deposited by the public.
- It can also issue currency by accepting government securities through open market operation, specifically by purchasing government securities from consumers.
- It can similarly withdraw currencies by selling government securities to the public.
- Banks are required by law to reserve a certain amount of deposits with the central bank. By controlling this required reserve ratio, the central bank can control the monetary base directly.

3 Stock Approach of the ASD Model

ASD Macroeconomic models presented in the book [5, 2013], including the one in chapter 9 just discussed above, differ from the current mainstream macroeconomic models such as neoclassical DSGE (Dynamic, Stochastic General Equilibrium) models and Keynesian econometric models in the sense that (1) ASD models are all based on the accounting system dynamics, (2) money (credits) is endogenously created and destroyed in the economy, and (3) they are disequilibrium models. These different features are made possible by the analytical method of the accounting system dynamics presented in chapter 3 in [5, 2013].

Under this analytical method, however, two distinct modeling processes of credit creation are shown to exist. Chapter 5 of the book explains these two processes in detail; that is to say, a traditional (or textbook) flow approach and stock approach. In a traditional approach of credit creation, banks make loans out of the deposits they receive from households; in other words, loanable fund approach. In a stock approach, banks make loans (credits) first to the borrowers' accounts out of nothing. If the amount of created credits (specifically, deposits) exceed the required reserves against them in the central bank, banks make re-adjustments of the required amount, after the loans are made, through inter-banking borrowing and lending transactions among them. This stock approach is closer to the real transactions daily practiced by commercial banks.

Recently, quite a few economists began to emphasize that the macroeconomic textbook approach is flawed and that loans are only handled through the stock approach in real transactions. Specifically, researchers at the Bank of England emphasized the importance of this stock approach in [2, 2014].

As a matter of fact, ASD Macroeconomic Model of Japn [6, 2015] has challenged to construct the stock approach of the ASD model. Then, it is demonstrated by the same authors in the paper [7, 2016], as well as chapter 5 of the above book, that these two approaches to the creation of credits are equivalent at the macroeconomic level. Yet, the stock approach is shown to be more realistic at the microeconomic level of transactions.

Considering these lines of research, we have decided to adopt the stock approach of credit creation in our research here. This approach would be better for handling real financial transactions among banks on which the Flow of Funds data are based.

Difficulties in building ASD model by the stock approach take place in the treatment of money stock. Under the textbook (flow) approach, cash and demand deposits are not strictly distinguished, as in the current accounting practice of balance sheet, and all transactions are assumed to be performed through the payment of cash. Accordingly, savings are made out of cash and deposited with banks. Under the stock approach, money stock consisting of cash (currency outstanding or in circulation), demand and time deposits have to be conceptually distinguished. As a result, major transactions are assumed to be made through demand deposits at banks, and savings are made out of demand deposits.

Central Bank as Government's Bank

The exception is the deposit account by the government. Government can make all transactions, receipts of all types of levied taxes and payment expenditures through its deposit account at the central bank. Accordingly, major transactions of the central bank are summarized as follows.

- In addition to the transactions mentioned above, central bank plays a role of government bank, and opens demand deposit account for the government. All government transactions such as collecting taxes and spending its expenditures are performed through this government's deposit account at the central bank.

This consequential expansion of the model to the stock approach is done by Yokei Yamaguchi [8, 2017]. Hence, in our research we are using his generic model of stock approach as a fundamental model of our Turkish macroeconomic model.

Yet, it is still a closed macroeconomic model. Consequentially, we are forced to expand this generic stock approach of ASD model to include overseas sector.

Stock Approach of the Open ASD Model

As discussed above, stock approach of ASD model by Yokei Yamaguchi is still a closed model. ASD macroeconomic model of Japan [6, 2015] is an open model of stock approach. Yet, it is a very big and complicated model and is not completed yet. Accordingly, we are obliged to newly construct an open ASD model in this research by incorporating overseas sector as follows[1]

[1]It turned out that the construction of our open ASD model is not so easy as originally expected due to the double-entry bookkeeping nature of overseas transactions. Kaoru Yam-

Overseas

- All trades of imports and exports as well as capital flow are performed with overseas sector. Payments of such foreign exchange transactions are assume to be made through the domestic and foreign central banks' foreign exchange accounts.

Figure 2 is a double-entry bookkeeping format of balance sheets by six macroeconomic sectors. We heavily use this format in our research to clarify our standing points of arguments whenever our arguments get lost in the air. It is presented here so that the readers may also find it useful for the clarification of their macroeconomic analysis.

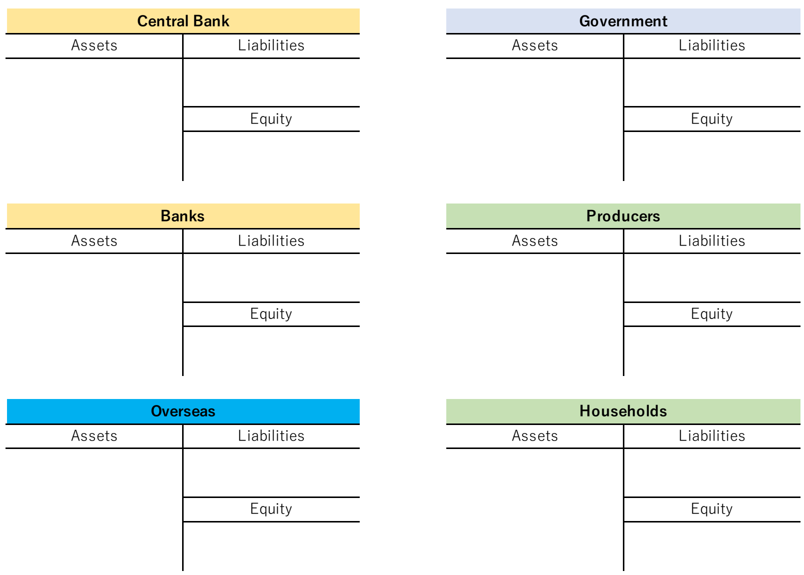

Figure 2: Double-booking Format of Six Sectors

Now our generic ASD model at this first phase of model development is illustrated in the Appendix.

4 Flow of Funds in the ASD model

4.1 Flow of Funds by the Bank of Japan as our Benchmark

The Bank of Japan (BoJ) provides comprehensive data of financial transactions to the public, indeed, very good public services to the researchers like us. It is

aguchi and Yokei Yamaguchi decided to follow the analytical method of overseas economy as a mirror image of domestic economy in [5, Chapter 10, 2013], and successfully developed the open ASD macroeconomoic model presented here. Accordingly, its copyright © belongs to them.

called "The Flow of Funds Accounts" (hereafter called the FFA). It is explained in the Guide to Japan's Flow of Funds Accounts[2] as follows.

> The FFA is based on the System of National Accounts 1993 (the 1993 SNA), a new international standard for national accounts that includes the FFA and Monetary and Financial Statistics Manual (the IMF Manual), compiled by the IMF, to standardize financial statistics. The 1993 SNA and the IMF Manual set the classification criteria for sectors and transaction items that will be common in various countries, which the FFA has basically embraced. Therefore, the FFA conceptually contributes to part of the macro statistic (the SNA) that records a country' s economic activities, and its basic concept of statistics is consistent with that of the national accounts in Japan (p.3).

BoJ's FFA is known among researchers as one of the most comprehensive data set. Hence, we decided to consider it as a point of reference for our Flow of Funds research in Turkey. Let us briefly review its structure.

Sectors

BoJ's FFA is provided in a matrix format. The columns into which economic entities are classified are known as "sectors." They are broadly divided into six sectors, and these sectors are further broken down into sub-sectors. In total there are 45 sectors (Data series of "Postal savings" and "Private life insurance companies" are available only until the third quarter of 2007).

ASD macroeconomic model of Japan [6, 2015] has selected the following 10 sectors and sub-sectors as essential for describing financial transactions in the Japanese macroeconomy. Following the FFA numbering below, they are 11, 12, 131, 132, 14, 2, 3, 33, 4, 6.

1. Financial institutions
    - 11 Central Bank
    - 12 Depository corporations (called here Banks)
    - 13 Insurance and pension funds
        - 131 Insurance (called here Insurance Companies)
        - 132 Pension funds
    - 14 Other financial intermediaries (called here Securities Companies)
2. Nonfinancial corporations (calle here Producers)
3. General government (called here Government)
    - 31 Central government

[2] Guide to Japan's Flow of Funds Accounts is available at https://www.boj.or.jp/en/statistics/outline/exp/exsj01.htm/

32 Local government

33 Social security fund
(called here Government Pension Investment Fund, GPIF)

4. Households

5. Private nonprofit institutions serving households (neglected here)

6. Overseas

Transactions

In the FFA matrix, transaction items are classified along horizontal lines as financial instruments (transactions, or assets and liabilities). items." They consist of totaled items such as "Currency and deposits," "Loans," "Securities other than shares," "Shares and other equities," and "Insurance and pension reserves" etc., and their sub-items. In total there are 51 transaction items (matrix rows) in the FFA.

To sum, there are 51 rows (transactions) and 45 columns (sectors), that is, 2,295 cells in the FFA matrix. Accordingly, time series data from 1980 through 2017 includes total data of 87,210. If it is a quarterly data, it contains 348,840 data. Thus, the Guide says "Such detailed classification allows users to rearrange the classifications in various ways in order to obtain different perspectives of the flow of funds (p. 2)."

4.2 Flow of Funds Data by DataTurkey

For our Flow of Funds research in Turkey, we are fortunate to be able to use the Flow of Funds data organized by DataTurkey group[3]. Their time series data are arranged between 2002 and 2013. Moreover, these data are collected in terms of TL and FX, which turn out to be very useful for our analysis of Turkish macroeconomic behaviors[4].

We have organized Turkish Flow of Funds sectors and transaction items according to the Japanese FFA' framework. But due to the availability of data our Turkish Flow of Funds turned out to be very simple as shown in Figure 3, specifically, 14 sectors and 29 transaction items.

4.3 Constraints of Flow of Funds Data

Though Flow of Funds data are large, there still exists constraints for utilizing them in our modeling research. Specifically, all financial transactions are

[3]Their data are made available through https://datatr.net.

[4]Technically speaking, the breakdown of data into TL and FX requires the split of stocks such as Demand Deposits into Demand Deposits (TL) and Demand Deposits (FX), causing our model more complicated and time-consuming to complete it. Consequentially, we are forced to expand the model, which is still taking place at this moment of writing.

Financial Instruments	*Maturity*	*Currency*	*CODE*
Currency & Deposits			A
Cash			A-a
	N/A	TL	A-a-a
		FX	A-a-b
Deposit			A-b
	Demand Deposit	TL	A-b-a
		FX	A-b-b
	Time Deposit	TL	A-b-c
		FX	A-b-d
Loans			C
	Short Term	TL	C-a
		FX	C-b
	Long Term	TL	C-c
		FX	C-d
Bonds			D
	Short Term	TL	D-a
		FX	D-b
	Long Term	TL	D-c
		FX	D-d
Shares			E
	N/A	TL	E-a
	N/A	FX	E-b
Insurance Technical Reserves	N/A	TL	F
Derivatives	N/A	TL	G
Trade Credit			I
	N/A	TL	I-a
	N/A	FX	I-b
Other (Mainly Accounts Payable/Receiva	N/A	TL	J
Monetary Gold and SDR	N/A	TL	M

Institutional Sectors	*CODE*
Financial Institutions	1
Central Bank	1-1
Depository Banks	1-2
Deposit Accepting Banks	1-2-1
Participation Bank	1-2-2
Other Financial Intermediaries	1-3
Financial Auxillaries	1-4
Non-Financial Corporations	2
General Government	3
Central Government	3-1
Local Government	3-2
Social Security	3-3
Households+NPISH	4
Overseas	6

Figure 3: Lists of Sectors and Transaction Items in DataTurkey

provided as *net flows* of sectoral stocks, because they are calculated as the differences between this year's stock values and those of previous year.

These stock values are collected from financial statements or balance sheets of all sectors. According to this nature of data calculation, specific data of inflows and outflows of financial transactions are impossible to be calculated, though it is crucial to identify where transaction funds come from and where they go out.

5 Validation Tests of the ASD Model

Our ASD model at this phase 1 has more than 700 variables, most of which are inter-connected through transactions of bank deposits. Accordingly, model validation test becomes very crucial before we move to the second phase of our research. We have performed our model validation through the following three tests.

Test 1 (Model and Unit Checks) There are two built-in model checks in Vensim; that is, Check Model and Check Unit. Our model has cleared all these check points.

Test 2 (Balance Sheet Test) Balance sheets of 6 sectors have to be in balance between total assets, and total liabilities plus net assets (or equities, including retained earnings). That is, for each sector the following equation has to be met.

$$\text{Sum of Assets} = \text{Sum of Liabilities and Equity} \tag{1}$$

Our model has cleared these balance sheet checks of all sectors.

Test 3 (Flow of Funds Test) Inter-sectoral assets and liabilities of all transaction items have to be in balance, item by item. For example, demand deposits of banks as bank liabilities have to be equal to the sum of all deposits accounts among non-bank sectors as assets. As another example, reserves at central banks (liabilities) has to be equal to the sum of reserves at banks as assets. That is, for each transaction item, the following equation has to be met.

$$\text{Sum of Item as Assets} = \text{Sum of Item as Liabilities} \tag{2}$$

Our model has cleared all these inter-sectoral checks.

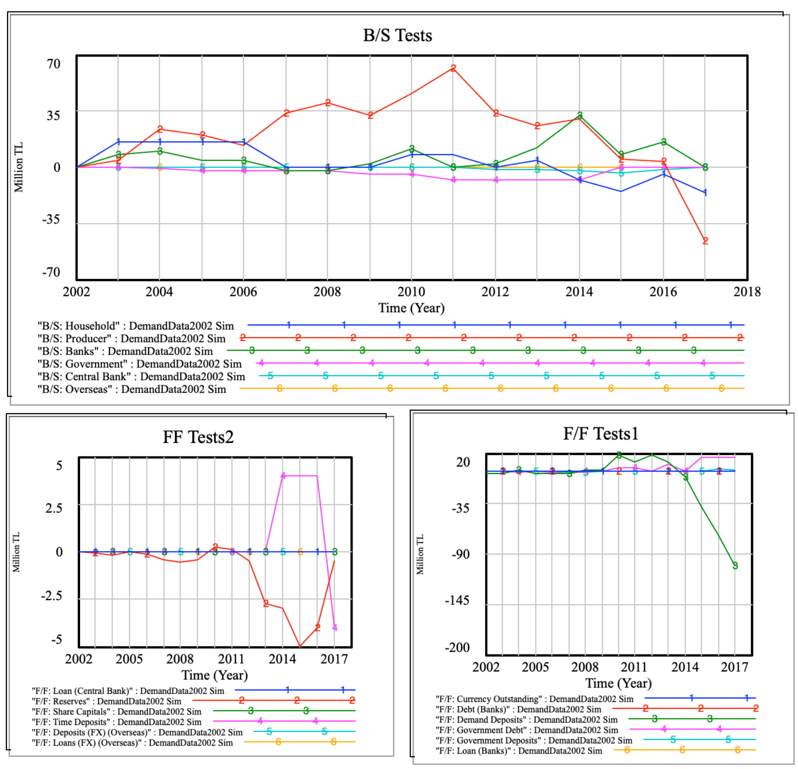

Figure 4: Balance Sheets and Flow of Funds Tests

Figure 4 illustrates Balance Sheet tests for 6 sectors, and Flow of Fund tests for 12 transaction items. Some minor imbalances appear due to the technical time delay of stock-flow calculation in these magnified diagrams of detailed observation. Yet, compared with large stock values, they are negligible. That is to say, they are all in balance.

6 Partial Optimization 1: Population

At the phase 1 of our research, we have successfully constructed our generic ASD macroeconomic model of Turkish economy. At this phase we have operated three partial optimization simulations to estimate fundamental parameter values of the economy, simply because behaviors of these optimizations could be observed more independently without considering feedback influences from the rest of the model, to a certain degree[5].

Variables of Payoff Definition

For the partial optimization of population, four variables are selected to calculate payoffs of the calibration optimization; that is, Total Population, Population 0 to 14, Population 15 to 64 and Population plus 65. To attain their relatively equal contributions to payoffs, they are weighted as 10, 30, 16, and 16.

Total fertility data is used as a model data for this partial optimization. Figure 5 is what we have obtained.

0 <= mortality 0 to 14 = 1.02109e-06 <= 0.03
0 <= mortality 15 to 44 = 0 <= 0.03
0 <= mortality 45 to 64 = 0 <= 0.03
0 <= mortality plus 65 = 0.0820992 <= 0.1
15000 <= INITIAL Population 0 to 14 = 18042.9 <= 40000
20000 <= INITIAL Population 15 to 64 = 40649 <= 60000
2000 <= INITIAL Population plus 65 = 6785.32 <= 8000
0.5 <= Portion to 15 to 44 = 0.938312 <= 1
20 <= reproductive lifetime = 29.3724 <= 30

Figure 5: Optimization parameter values for population

[5] To be precise, this may not be appropriate, because some parameters could be still made interdependent by the nature of the macroeconomic system. The purpose of these partial optimizations is to illuminate the overall framework of the model as a first step toward a more comprehensive analysis at the later phases.

Figure 6 is a report on the validation of this optimization.

Source	GDP Data (2002-2017).vdf			
Component	Total population/10	Population 0 to 14/30	Population 15 to 64/16	Population plus 65/16
RSquare	0.985204	0.668335	0.974619	0.399015
DW	0.077031	1.00552	0.180658	0.0926811
Autocor1	0.845944	0.784139	0.885212	0.999335
Autocor2	0.46034	0.230523	0.530375	0.997126
Autocor3	0.031869	-0.412851	-0.0554887	0.994144
Autocor4	-0.319621	-0.817586	-0.598996	0.992816
(TimeGap)	1	1	1	1
RMSE	509.246	149.602	393.413	377.15
Um	0.680341	0.257972	0.361483	0.423103
Us	0.0115056	0.147393	0.287921	0.431004
Uc	0.308154	0.594635	0.350596	0.145893
MAE	420.04	125.912	355.415	273.717
MAPE	0.574963	0.641927	0.730282	5.39875
MAEoM	0.577058	0.639884	0.724457	4.98438

Figure 6: Payoff Report on Population

Figure 7 and Figure 8 demonstrate calibrations of total population and its cohorts by optimization.

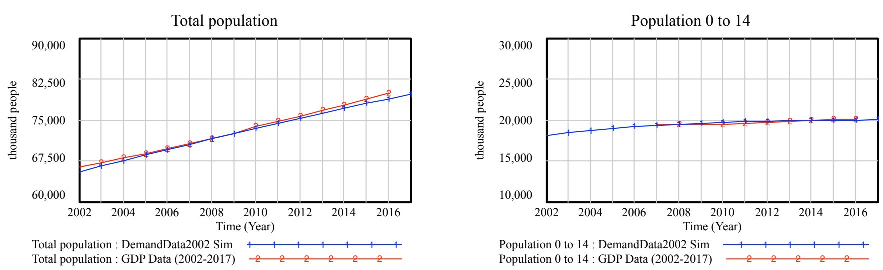

Figure 7: Total Population and Population 0-14

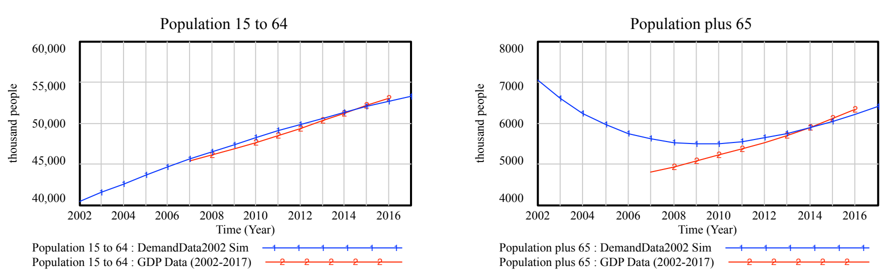

Figure 8: Population 15-64 and Population 65+

7 Partial Optimization 2: Labor Force

Variables of Payoff Definition

For the partial optimization of labor force, three variables are selected to obtain payoffs of the calibration optimization; that is, Labor Force, High School Students and College Students. To attain their relatively equal contributions to payoffs, they are weighted as 10, 150 and 63.

Figure 9 is what we obtained.

```
0.1 <= college attendance ratio = 0.496396  <= 0.7
1 <= high schooling time = 5.4296  <= 6
10000 <= INITIAL Voluntary Unemployed = 84701  <= 100000
16000 <= INITIAL Employed Labor = 17007.5  <= 25000
2000 <= INITIAL High School Students = 4955.6  <= 5000
2 <= college schooling time = 17.2873  <= 20
```

Figure 9: Optimization parameter values for Students and Labor Force

Figure 10 is a report on the validation of this optimization.

Figure 11 demonstrates the optimization of high school and college students. Figure 12 demonstrates the optimization of labor force. As a reference, employed labor is also illustrated, though not included in the payoff definition.

Source	GDP Data (2002-2017).vdf		
Component	College Students/150	High School Students/63	Labor Force/10
RSquare	0.768599	0.442851	0.97877
DW	0.138427	0.583343	0.468603
Autocor1	0.930904	0.681889	0.752832
Autocor2	0.756994	0.317877	0.216163
Autocor3	0.446372	-0.289872	-0.162101
Autocor4	0.0314667	-0.381053	-0.604612
(TimeGap)	1	1	1
RMSE	672.772	818.559	406.875
Um	0.129137	0.00210192	4.93E-07
Us	0.240392	0.359996	7.82E-06
Uc	0.630471	0.637902	0.999992
MAE	522.205	710.921	312.364
MAPE	24.0796	10.9907	1.3176
MAEoM	16.4053	11.5733	1.24086

Figure 10: Payoff Report on Students and Labor Force

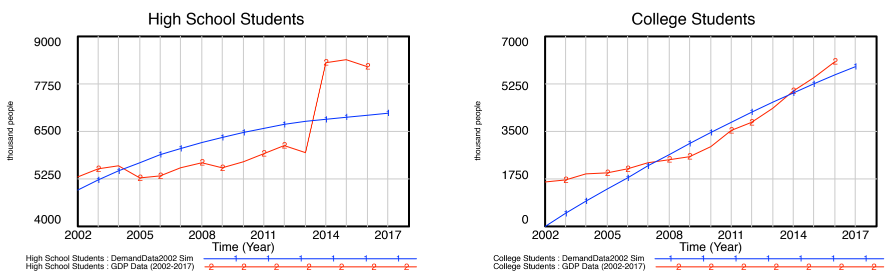

Figure 11: High School and College Students

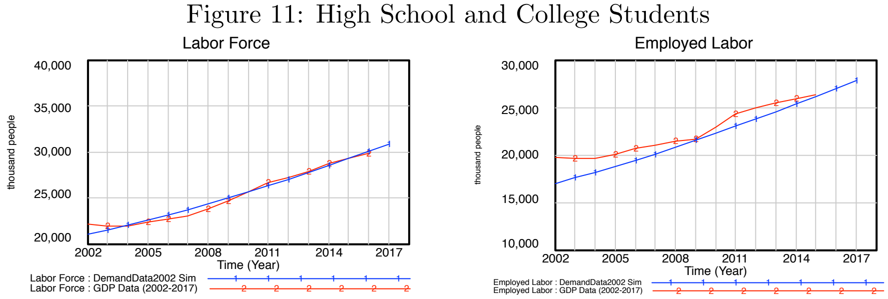

Figure 12: Labor Force and Employed Labor

8 Partial Optimization 3: Real GDP and Price

Variables of Payoff Definition

For this partial optimization two variables are selected to obtain payoffs of the calibration optimization; that is, GDP (real) and Price. To attain their relatively equal contributions to payoffs, they are weighted as 1 and 7500.

As model data for this partial optimization, we have used aggregate demand data such as consumption, investment, government expenditures, exports and imports.

Figure 13 is what we obtained.

0 <= Technological Change = 0.0495281 <= 0.15
300000 <= Initial Potential GDP = 827390 <= 900000
2e+06 <= "Initial Capital (real)" = 3.37146e+06 <= 9e+06
0.05 <= Exponent on Capital = 1.13594 <= 10
0 <= Exponent on Labor = 0.549473 <= 2
0.01 <= Depreciation Rate = 0.0384121 <= 0.1
0.1 <= Time to Adjust Capital = 13.2419 <= 30
0.01 <= Time to Adjust Inventory = 1.71767 <= 8
0.1 <= Time to Adjust Forecasting = 0.220268 <= 10
0.01 <= Normal Inventory Coverage = 0.0624284 <= 5
0.1 <= Construction Period = 49.8945 <= 50
0.06 <= Delay Time of Price Change = 1.52829 <= 2
0 <= "Cost-push (Wage) Coefficient" = 3.76004 <= 8
0 <= "Output Ratio Elasticity (Effect on Price)" = 0.114156 <= 2
0 <= Weight of Inventory Ratio = 0.535158 <= 1
0.1 <= Delay Time of Wage Change = 0.18417 <= 4

Figure 13: Optimization parameter values for GDP and Price

Figure 14 is a report on the validation of this optimization.

Source	GDP Data (2002-2017).vdf	
Component	Price/7500	GDP (real)/1
RSquare	0.998423	0.998658
DW	1.07689	1.56634
Autocor1	0.420576	0.112845
Autocor2	0.102288	-0.537071
Autocor3	-0.531343	-0.102698
Autocor4	-0.626152	0.193455
(TimeGap)	1	1
RMSE	1.34493	9429.72
Um	0.0371217	0.00165795
Us	0.101147	0.0111891
Uc	0.861731	0.987153
MAE	1.11473	8105.19
MAPE	1.07955	0.705095
MAEoM	1.07898	0.722859

Figure 14: Payoff Report on GDP (real) and Price

Figure 15 demonstrates visualized optimization results of GDP (real) and Price.

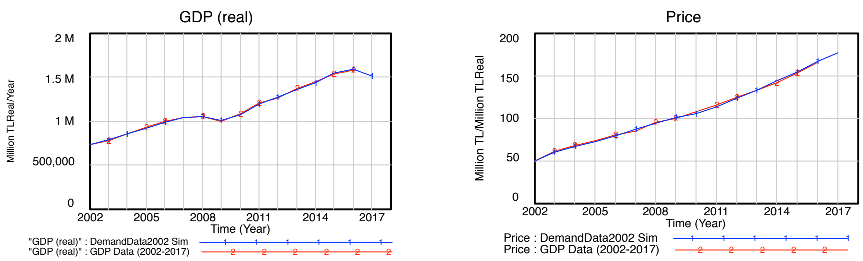

Figure 15: Optimization of GDP (real) and Price

9 Behavior Reproduction Tests

9.1 Model Testing Measures

So far we have discussed three partial optimizations for the Turkish macroeconomic model; that is, population, labor force and real GDP-price. How can we validate these results obtained from our reproduction modeling?

As behavior reproduction tests, we follow the measures proposed in chapter 21 by John Sterman [3, 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.

$$R^2 = r^2; r = \frac{1}{n}\sum \frac{(X_d - \bar{X}_d)}{s_d}\frac{(X_m - \bar{X}_m)}{s_m}, \tag{3}$$

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 [3, 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

$$\text{MSE} = \frac{1}{n}\sum (X - X_d)^2. \tag{4}$$

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 vaiances 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 [3, p.875].

How can we use this breakdown measures of MSE, then, to evaluate our simulation results? Sterman 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)."

9.2 Model Testing for Population

With these measures in mind, we are now in a position to test our simulation results. Figure 6 reports our optimization results on four variables such as Total population, Population 0 to 14, Population 15 to 64, and Population plus 65. Their R^2 values are 0.985, 0.668, 0.975 and 0.399, respectively. Except Population plus 65, all other variables realize the value almost close to one; that is, very nice fitting.

Concerning the Theil inequality statistics, except Population plus 65 ($U^c = 0.145$), all other U^c reveal relatively high values, that is, 0.3, 0.59 and 0.35, respectively, indicating their errors are *unsystematic*. Errors of U^m for Total Population is 0.68; that is, high enough to pay further attention.

9.3 Model Testing for Labor Force

Figure 10 reports our optimization results on three variables such as College Students, High School Students and Labor Force. Their R^2 values are 0.769, 0.442 and 0.979, respectively. Except High School Students, other two variables realize pretty nice fitting.

Concerning the Theil inequality statistics, U^c errors for all three stocks are pretty high; that is, 0.63, 0.64, and 0.99, respectively, indicating they are all *unsystematic*. However, R^2 of High School Students is 0.442 and not well fitting, yet its high U^c reveals that fitting errors may be noises and *unsytematic*.

9.4 Model Testing for GDP (real) and Price

Figure 14 reports our optimization results on two variables such as GDP (real) and Price. Their R^2 values are 0.998 and 0.999, respectively; that is, they are very close to one, demonstrating very nice fitting with data.

Concerning the Theil inequality statistics, two U^c reveal relatively high values; that is, 0.86 and 0.99, indicating their errors are *unsystematic*. Specifically, errors of U^c for Price is very close to one, indicating that our model is *unsystematic*, only driven by random noises. Meanwhile, U^s of GDP (real) is 0.101 and may reveals some systematic errors that may draw our attention.

In summary, our ASD macroeconomic model for Turkish economy can be said to be well constructed as the Phase 1 research.

10 Some Findings from GDP (real) Optimization

10.1 Production Capacities

Production function used in the model is defined as

$$Y_{full} = e^{\kappa t} \bar{Y}_{potential} \left(\frac{K}{\bar{K}} \right)^{\alpha} \left(\frac{L}{\bar{LF}} \right)^{\beta} \tag{5}$$

where

$$\bar{Y}_{potential} = F(\bar{K}, \bar{LF}, \bar{A}) = \bar{A}\bar{K}^{\alpha}\bar{LF}^{\beta} \quad \text{(Initial Potential Output)}, \qquad (6)$$

and α and β are exponents on capital and labor, respectively.

Based on this production function, we have estimated several parameter values for Turkish production capacities as shown in Figure 13 between the period 2002 through 2017. Here are three findings on Turkish production capacities from our simulation results.

- Technological progress of Turkish economy is close to 5%, pretty high contribution by technological advances.
- Capital depreciation rate is 3.8%, which means capital equipments are replaced every 26 years as a simple calculation.
- Exponent on Capital (α) is 1.1 while Exponent on Labor (β) is 0.55. This implies, Turkish production depended relatively on capital. Since $\alpha + \beta = 1.65$, Turkish economy realized increasing returns to scale; that is, output increases factor of 1.65 for the increase in inputs of capital and labor.

10.2 Inflation

Figure 16 illustrates comparative behaviors of nominal and real GDP. Specifically, line 1 shows the optimized GDP (real) and line 2 shows its data values. Line 3 is the calculated nominal GDP and line 4 is nominal GDP data. When nominal GDP is deflated, more flat real GDP appears. This indicates how large the inflation rate has been during the period 2002 and 2017.

Left-hand diagram of Figure 17 shows calculated inflation rate (line 1) and actual inflation rate obtained from GDP deflator data. They indicate that Turkish economy experienced very higher inflation during the period 2002 and 2008[6], just before the Financial Crisis in 2008.

What caused these higher inflation in Turkey, then? Right-hand diagram of Figure 17 is the flow of changes in price that affect price level, from which we can easily observe that demand-pull change in price (line 2) is very close to a total change in price (line 1). The other factor to the price change is a change in cost-push (wage), which is almost negligible. This implies that price change has been mainly caused by the demand-pull change in price.

[6] As a matter of fact, before 2002, Turkish economy suffered from hyper-inflation, including the denomination of 1 million TL into 1 TL

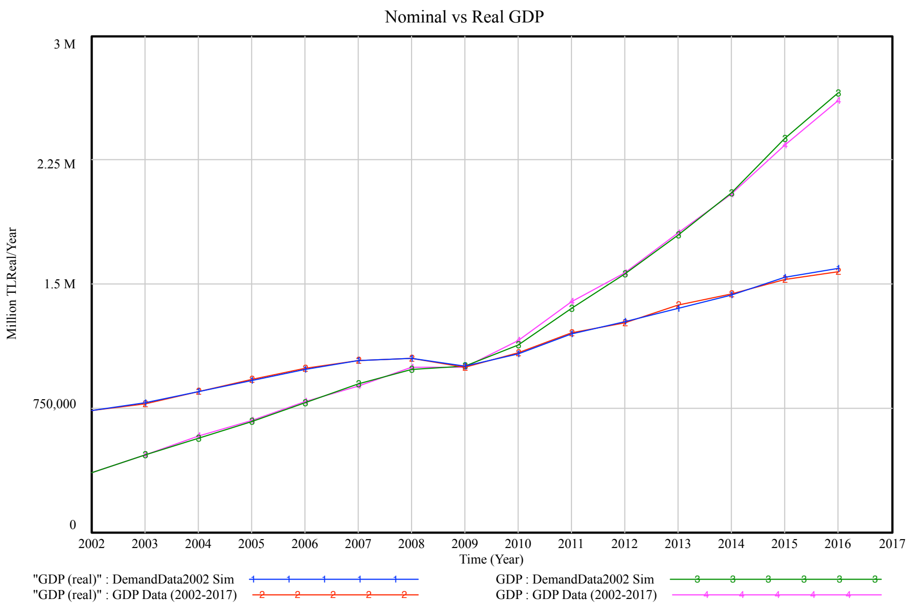

Figure 16: Nominal vs Real GDP

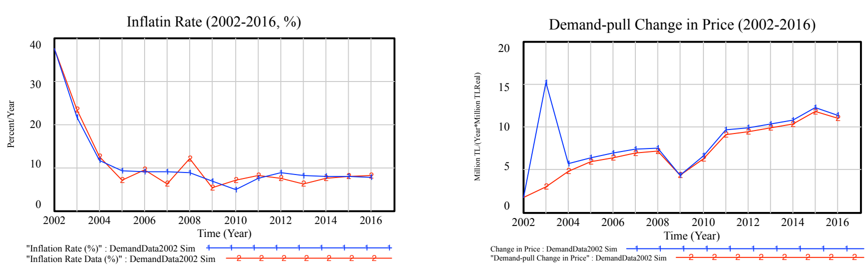

Figure 17: Inflation Rate and Demand-Pull Change in Price

Figure 18 shows Potential GDP (line 1), Full-capacity GDP (line 2), GDP (real) (line 3) and Desired Output (real) (line 4).

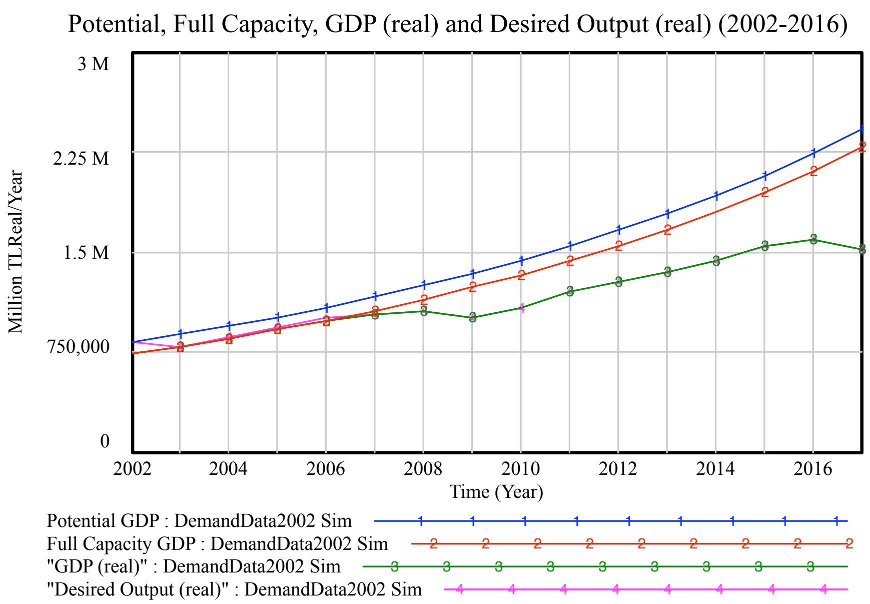

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Figure 18: Potential, Full Capacity and Real GDP

GDP (real) is determined such that

$$\text{GDP (real)} = \text{MIN(Full Capacity GDP, Desired Output (real))} \tag{7}$$

After 2002, Desired Output has been lower than Full Capacity GDP, and GDP (real) has been determined by the lower level of Desired Output, which subdues abnormal inflation (as Keynesian effective demand theory suggests). After the financial crisis of 2008, Turkish economy has been growing below full capacity GDP.

Figure 19 shows that Desired Output (real) (line 1) is equal to the sum of Aggregate Demand Forecasting (line 2) and Desired Inventory Investment (line 3). We can easily observe that strong desired output has been supported by the strong inventory investment.

Where does this strong demand inventory investment come from, then? Theoretically speaking, it has to be supported by the affluent amount of money stock. To investigate this deeper cause of inflation in relation with money stock, we have to wait for the next Phases of our research that integrate financial and

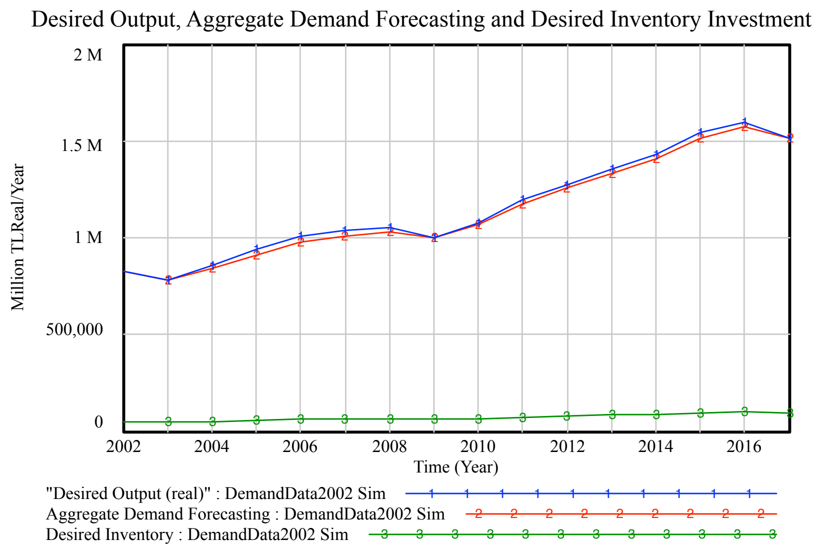

Figure 19: Desired Output, Aggregate Demand Forecasting and Desired Inventory Investment

banking behaviors. The purpose of this paper is to report that we have successfully attained Phase 1 of our research. Hence, our Phase I report concludes here.

Conclusion

This paper first discusses why ASD model is chosen for constructing the macroeconomic model of the Republic of Turkey. Then the expansion of our generic ASD model of stock approach to the open macroeconomy is discussed, together with the importation of the Flow of Funds data based on DataTurkey consisting of TL and FX data. Furthermore, three partial optimization simulations are performed to examine our model validation with the conclusion that our ASD model should not be faulted on the basis of Theil inequality statistics. Finally, some findings from these partial optimization are presented such as Turkish production capacities and inflation. In conclusion, our ambitious research of constructing the ASD macroeconomic model can be said to be well kicked off in Phase 1.

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Appendix: ASD Macroeconomic Model

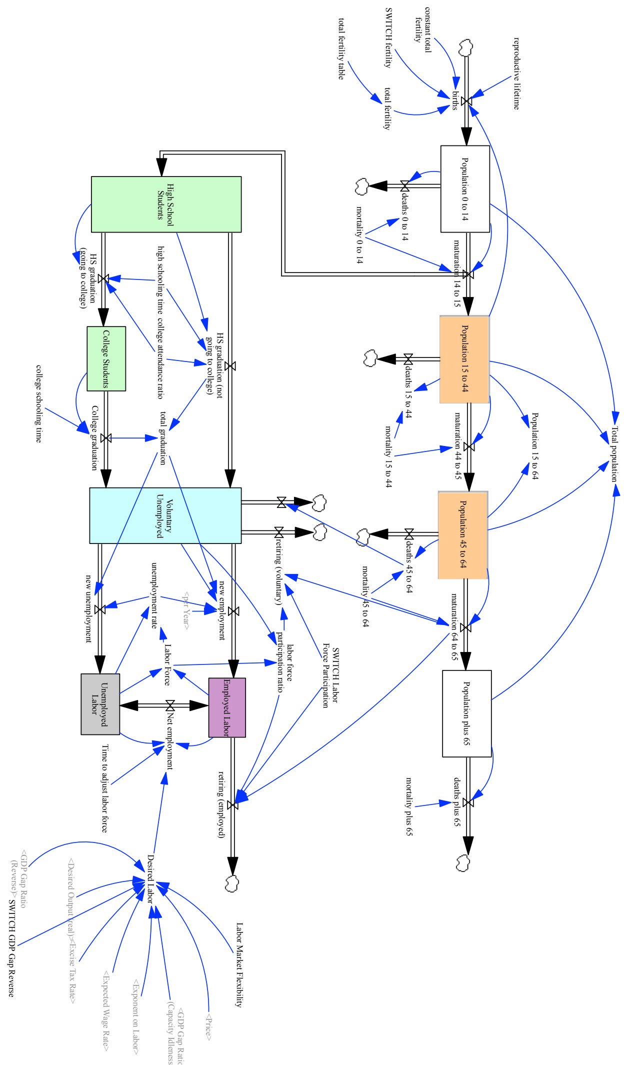

Figure 20: Population and Labor Market

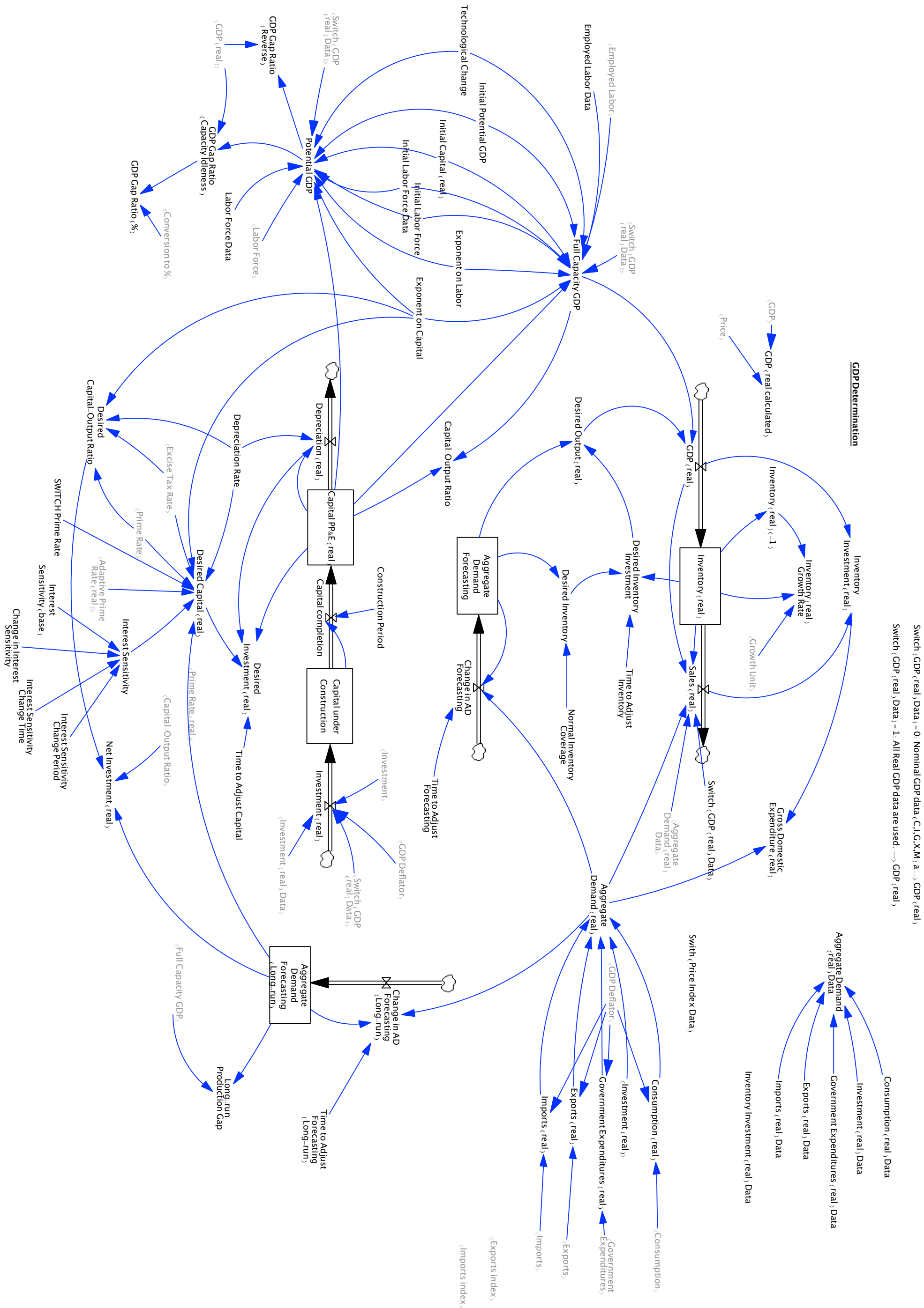

Figure 21: Real GDP Determination

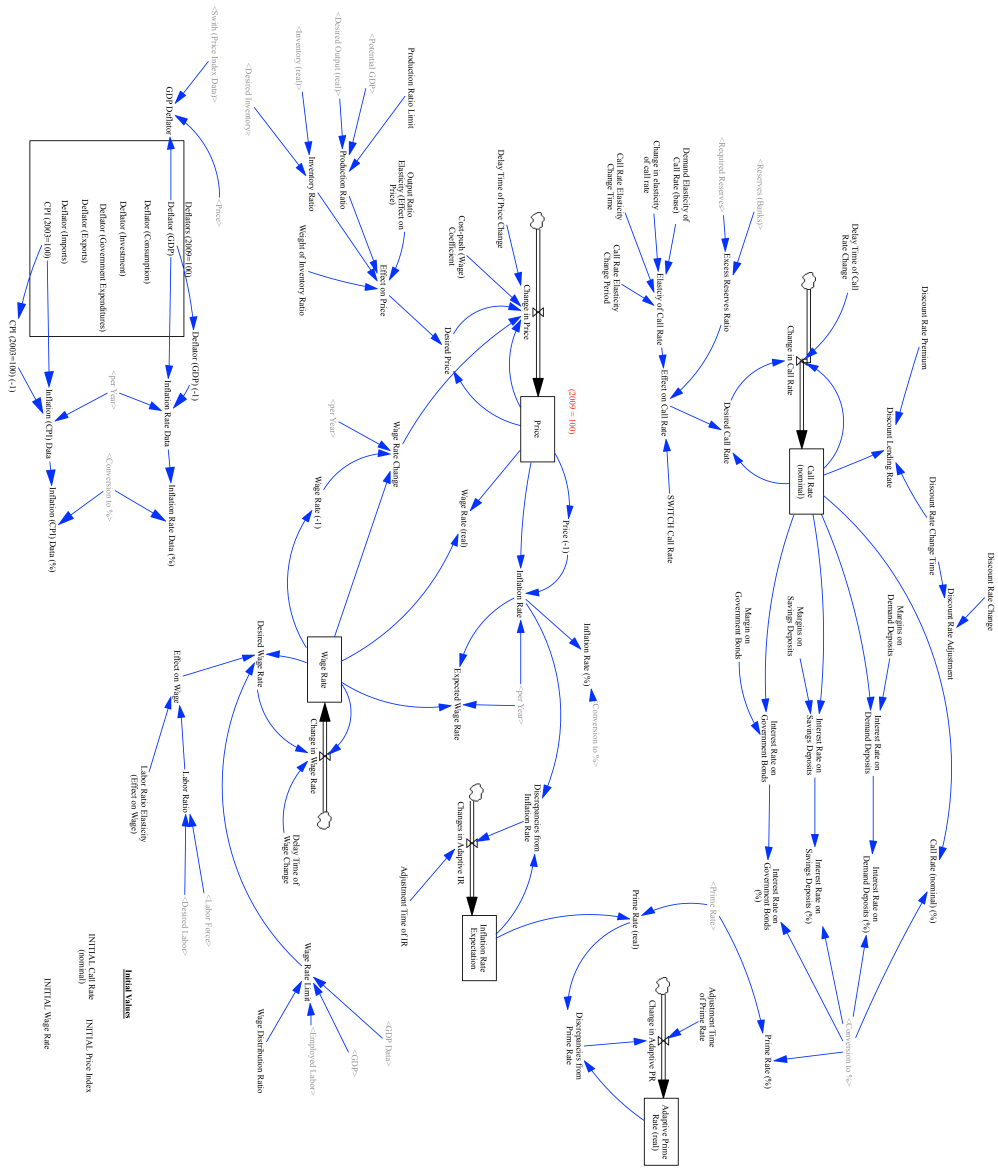

Figure 22: Price and Interest Rate Determination

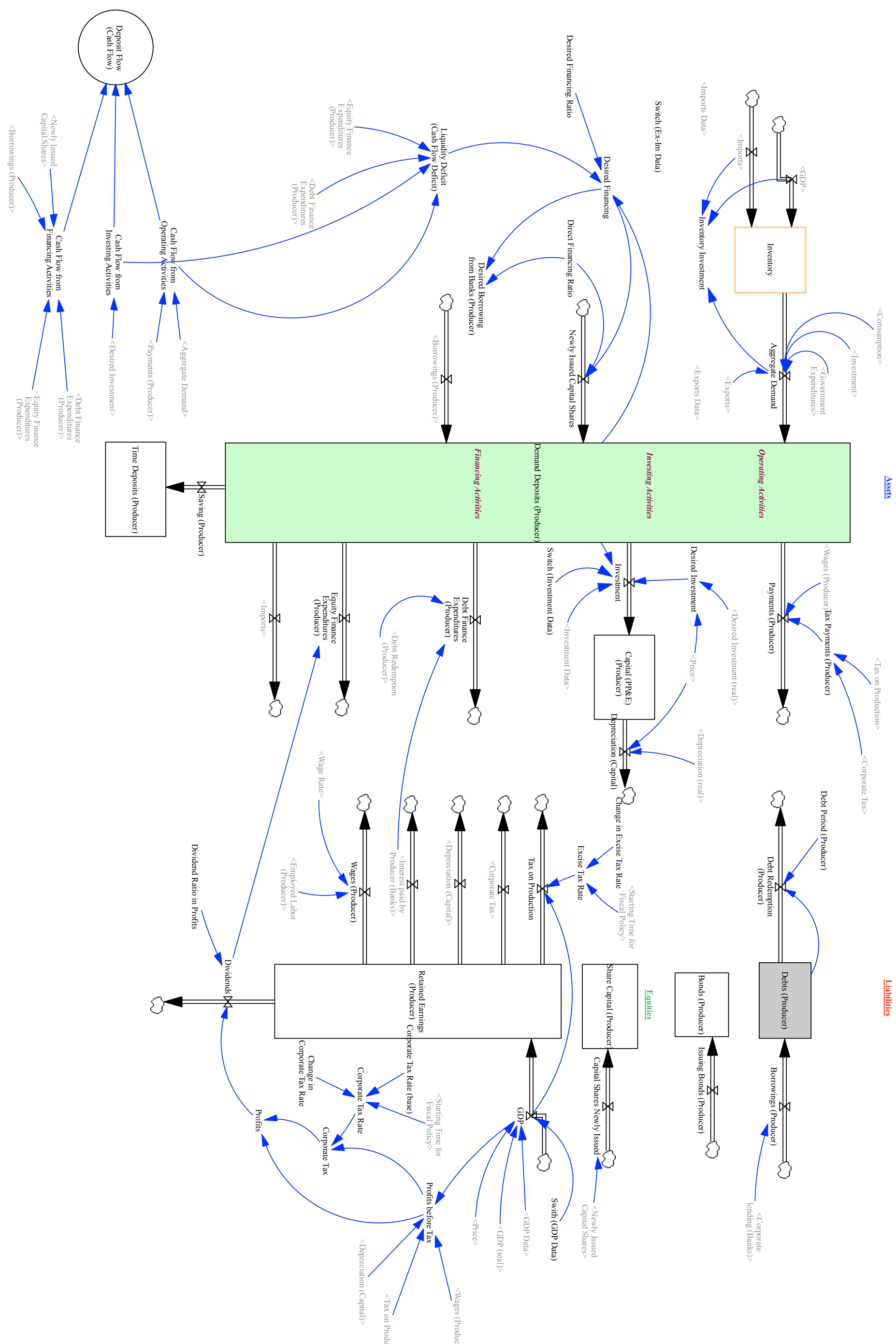

Figure 23: Producers Sector

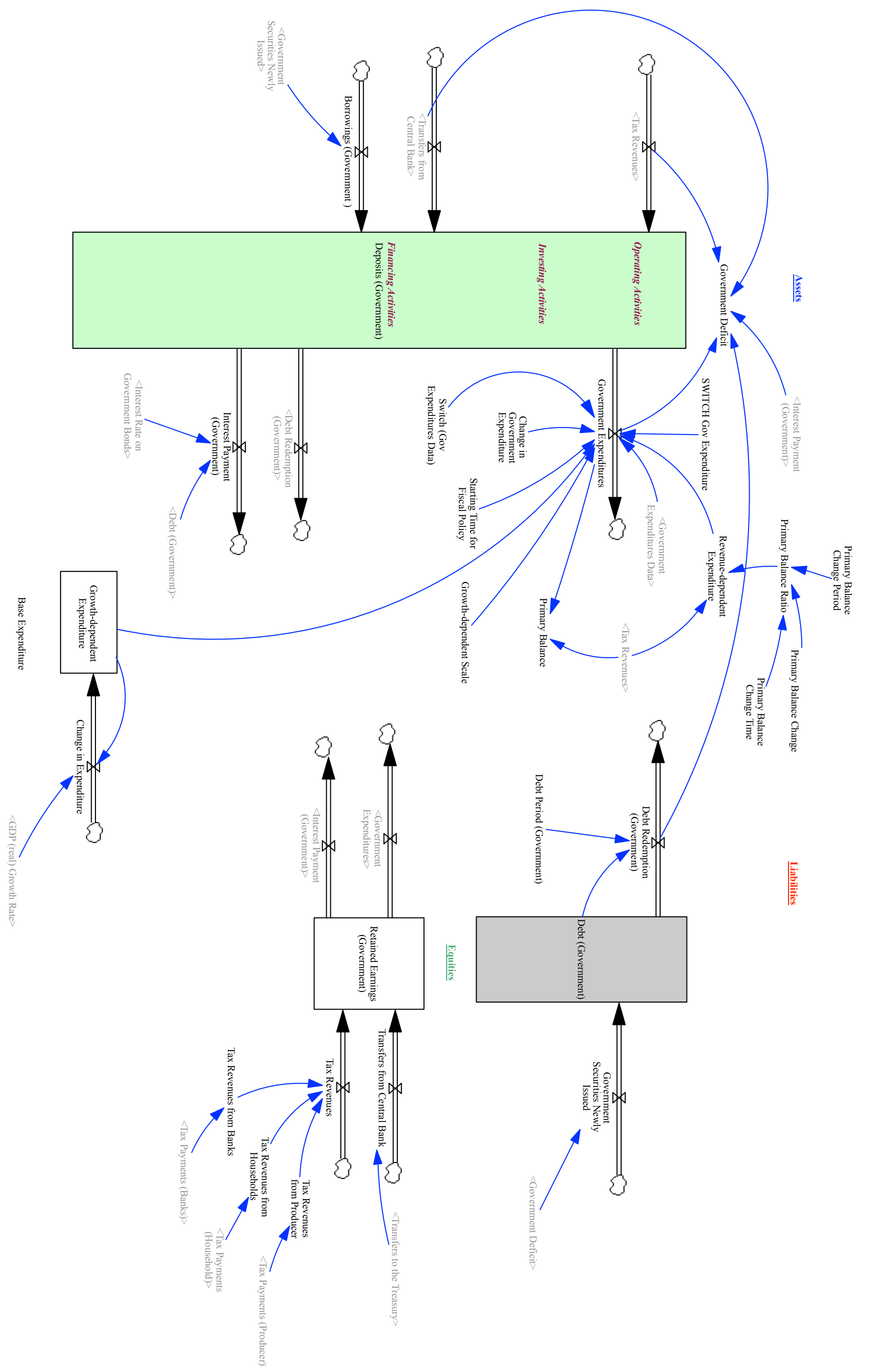

Figure 24: Households Sector

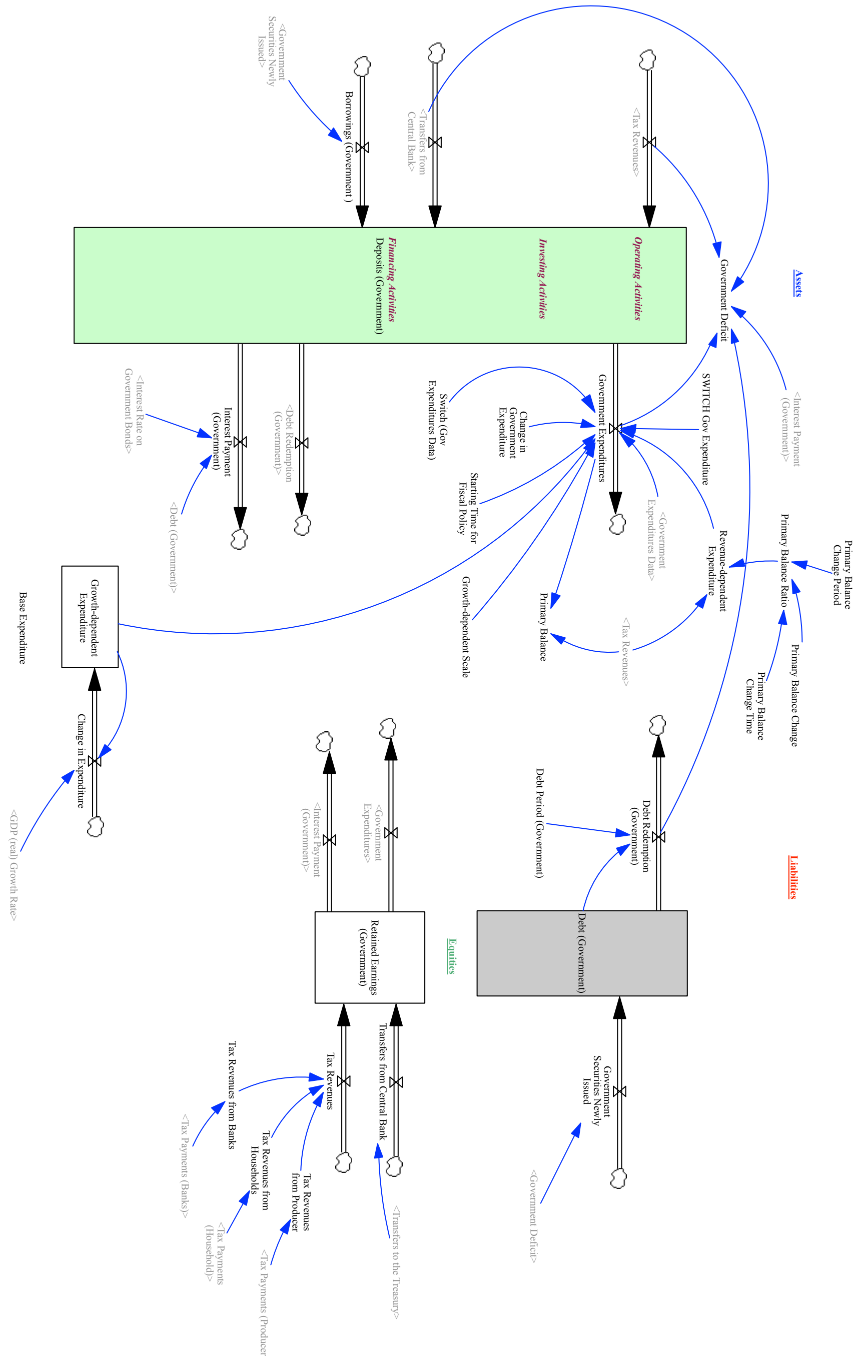

Figure 25: Government Sector

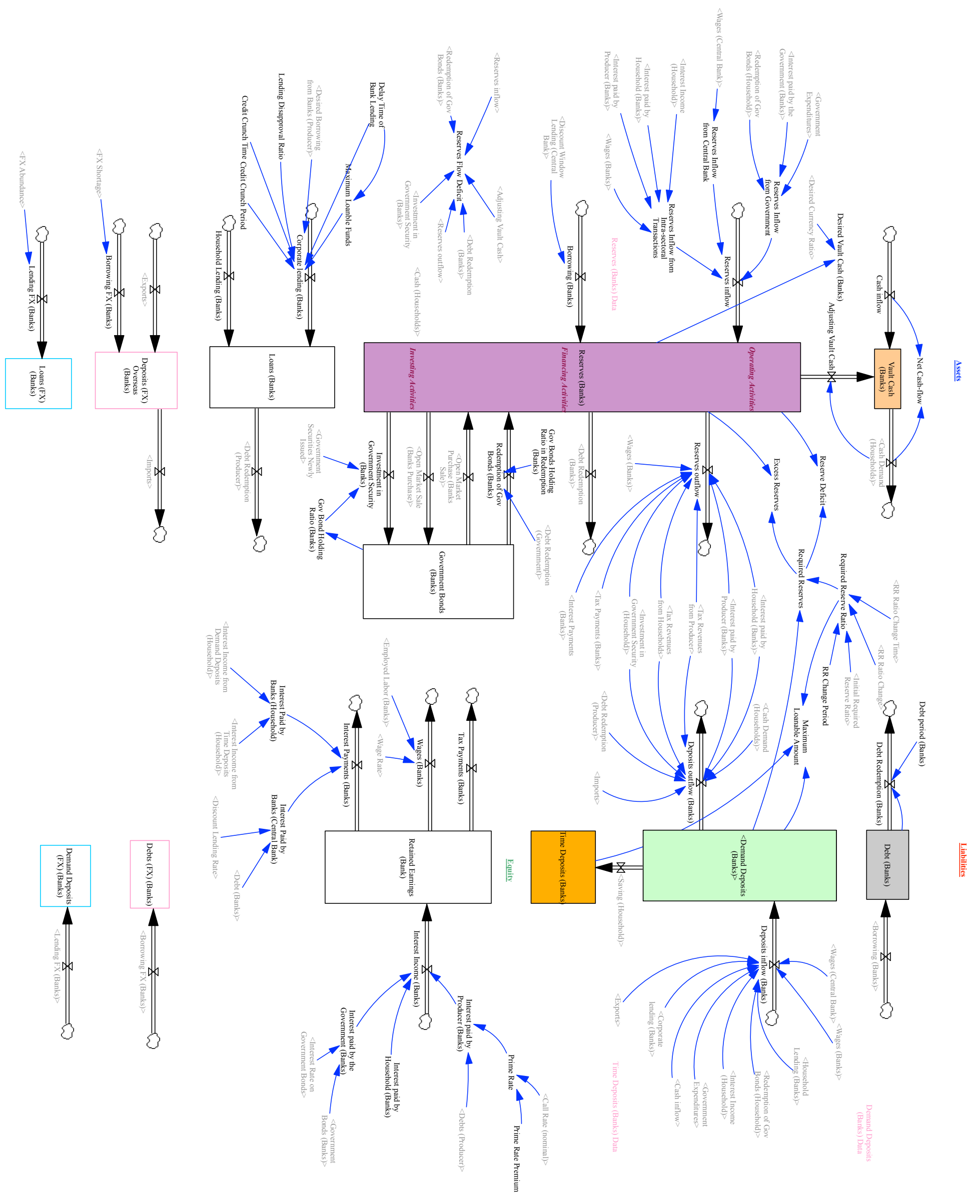

Figure 26: Banks Sector

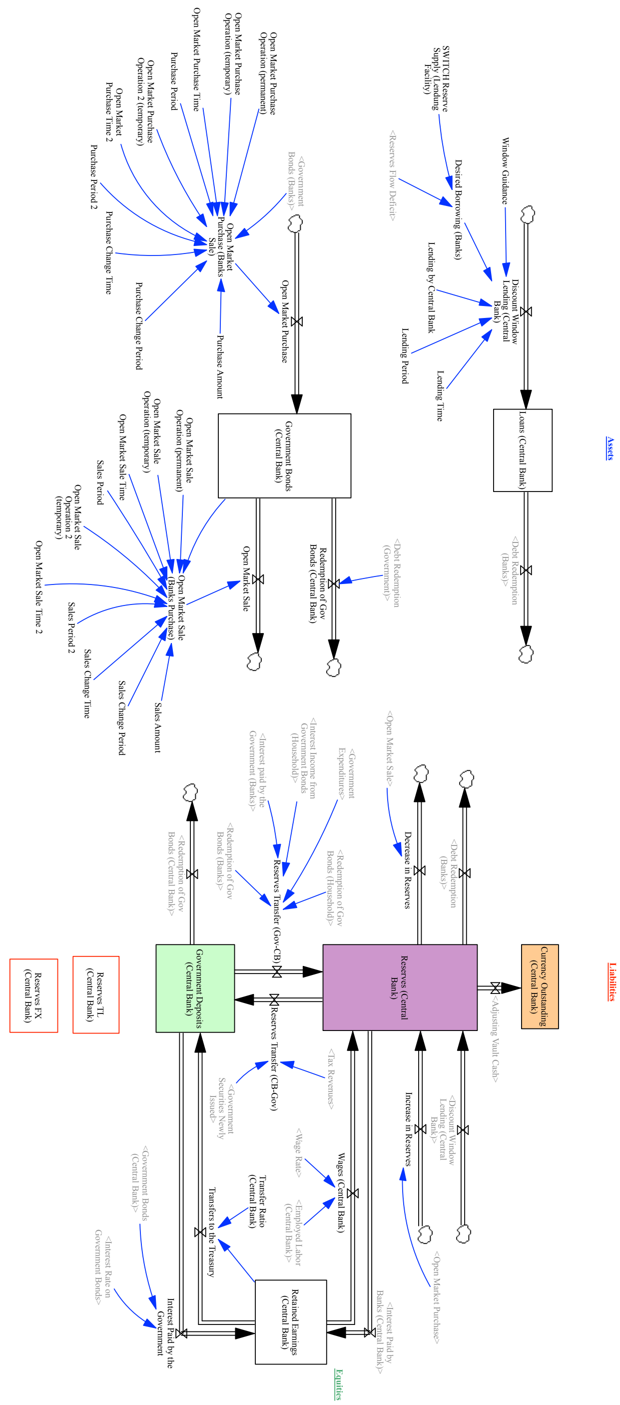

Figure 27: Central Bank Sector