Master Degree Project in Economics

Master Degree Project in Finance

Endogenous Money in Foreign Exchange Markets

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Abstract

This paper analyses the endogeneity of money creation or destruction when banks and central banks act in foreign exchange markets. From a historical analysis of banking operations it is derived that endogenous money in foreign exchange transactions originated together with banks as depository institutions. Combinations of central bank, banking system or non-banking system sectors interacting in foreign exchange markets are analysed. Modern banking systems when purchasing foreign currency pay with the issuance of newly created deposits. The analysis is performed using a 'balance sheet approach to money' methodology. Empirical evidence is provided with statistical analysis of the Swedish banking system's assets and liabilities, concluding that the Swedish banking system borrows foreign currency and exchanges it for domestic currency resulting in a bank money destruction. An exemplary stock-flow consistent model is presented inhibiting the effects of endogenous money in foreign exchange markets. In conclusion in the short-run foreign currency demand may be met with quantity increases instead of price increases and in the long-run it is relevant for economies on how foreign currency is obtained, by which sectors, and how it is used.

Contents

List of Balance Sheets, Figures and Tables

Balance Sheets

Figures

Tables

Appendix

Abbreviations and Glossary

BM (Bank money) A daily redeemable bank liability used for settlements in the form of a regular bank account.

CBM (Central bank money) A central bank liability used for settlements in the form of a central bank account or cash.

Currency Refers to the unit of money or the system of money that a country uses.

Deposit Daily accessible bank account with bank or central bank.

FX (Foreign Exchange) Foreign exchange market or sometimes also foreign currency.

IOU (I owe you) Any type of financial liability.

Money Supply Sum of different types of money such as bank money and central bank money.

1. Introduction

The recent financial and economic crises along with unconventional monetary policy have sparked public and academic interest in monetary economics. Nevertheless the mysticism around the exact causes of the financial crisis and the transmission mechanism to the economic crisis leaves most academics clueless. This is largely due to not taking into account in their models the proper workings of the constantly changing financial system.

A lack of research in this regard remains with economists still not even agreeing on the exact mechanisms of how money, the basic unit for all financial contracts, is created[1]. Money is often ignored in models as it is assumed to be neutral, such that it affects only nominal, but not real variables, and also that it is purely exogenously determined by the central bank.

This view is contested by some smaller schools of thought such as Monetary Circuit Theory and Post-Keynesian Economic Theory putting much emphasis on the workings of the financial system and possible real affects on our 'monetary economy' as opposed to a pure 'production economy' in which monetary effects don't matter.

Although endogenous money theories are at the heart of Post-Keynesian Economic Theory the area of foreign exchange is largely underresearched in this respect. While the behaviour of central banks is well documented, there are almost no accounts on banking systems endogenously creating money on their own due to foreign exchange transactions. In the conventional understanding the foreign exchange market is commonly only presented as an exchange of already existing money with exchange rate movements equilibrating supply and demand. Instead, the market structure, participants and clearing mechanisms of foreign exchange markets need to be examined.

The purpose of this paper is to provide a full account of money creation in foreign exchange transactions and clarify the endogeneity at hand. In addition it attempts to examine if the money creation due to foreign exchange is empirically relevant. At last the paper examines if there are gains in understanding from modelling foreign exchange markets with flexible quantity and price. The analysis attempts to build up on Post-Keynesian Economic Theory and expand on the research of monetary mechanisms relevant for the economy.

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[1] For an analysis of the contesting theories see Werner (2014).

The methodology following through the whole paper is that of the 'balance sheet approach to money' as explained by Wray (1990, ch. 9). It presents money as balance sheet items on the bank or central bank balance sheets. The chosen methodology enhances an understanding of money as a bank liability.

The examination begins with a historic outline in Chapter 2 explaining common banking operations with the use of simplified balance sheets. It allows an intuition on how it could happen that money is created in foreign exchange transactions.

The money endogeneity embedded in the current financial system and corresponding theories are presented in Chapter 3. This includes practices of monetary policy and banking systems' financing costs of purchasing foreign currency.

Chapter 4 describes the foreign exchange market with respect to relevant actors, settlement and exchange rate determination theories. Previous findings on money endogeneity in foreign exchange markets are presented in Chapter 5.

A detailed analysis of money creation and destruction in foreign exchange markets is presented in Chapter 6 displaying the different cases of banking systems, central banks and non-banking systems of two countries interacting with each other in foreign exchange markets.

Empirical evidence is presented in Chapter 7 with an analysis of the co-movement of individual assets and liabilities of the Swedish banking system's balance sheet displaying money endogeneity due to foreign exchange transactions.

A stock-flow consistent model is displayed in Chapter 8 in order to help illustrate the dynamics of foreign exchange modelling that ensure that money creation and destruction mechanisms are properly accounted for. These types of models allow a further understanding of foreign exchange market behaviour in light of endogenous money.

2. A Short History of Banking Operations

A short history of banking operations outlines how it could occur that banking foreign exchange transactions result in money being created. It is found that modern banking evolved from money changers precisely by overcoming troubles of many different types of coins through issuing high quality liabilities for the use of settlements. This chapter discusses the origins of modern banks and not theories of how and why money and credit came into existence, which would go back much further in time.

Nevertheless it must be mentioned that there exists discourse if money is what the state or community declares it to be, Knapp's state theory of money, or what markets use to fulfill the purposes of money, nominalism (Kindleberger, 1993, p. 22). In favour of Knapp's theory is that the power of taxation allows the state to enforce certain things as money, as can be seen in medieval England where the regular method of the government paying a creditor was by issuing hazelwood tally sticks. These could later be used in paying taxes (Innes, 1914; Wray, 2012).

The chapter is relevant in that it displays the origin and common practice of monetary creation.

The Origin of Banks

While primitive financial institutions were already used by the Romans, the analysis here begins with banking institutions arising in Italy in the eleventh and twelfth centuries (Wray, 1990, p. 33). The origins of modern banks are found in money changers, it is also where banks derive their name from with money changers using a bench '*banca*' to conduct their business (Kindleberger, 1993, p. 44f). Money changers were very active at fairs where many currencies met and needed to be exchanged. Bills of exchange[2] as a credit instrument and clearing at the end of fairs were already commonly used (Kindleberger, 1993, p. 39f). Wray (1990, p. 34f) explains that local money changers changed petty foreign coin into legal local tender, lent foreign coin, made small loans, took deposits and kept book of accounts, small overdrafts were allowed. Over time the lending to merchants increased and money changers started to keep accounts with one another to clear the settlement of debts, even through distance. All classic banking functions were therefore available.

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[2] Bills of exchange are a piece of paper denominating a debt contract that the holder of the bill receives a certain amount of money from a specified person or institution at a specific location at a predetermined point in time or on demand. Bills of exchange were commonly used fulfilling monetary functions as a means of payment (see pages 5-6).

Bagehot (1873, ch. 3) states the banking business in Italy to have flourished by making loans or floating loans for local governments of cities. He claims this to be enhanced by the tumultuous conflicts between the Italian Republics of the Middle Ages. Bagehot outlines that the banking business in Northern Europe had its origin in overcoming transactions performed in many different types of possibly clipped coin or bills of exchange denominated in various currencies. The uncertain value of these coins and bills of exchange led to the establishment of city banks as in Amsterdam.

The Bank of Amsterdam was created in 1609 as a deposit bank without the intent of extending credit, which is why it was created without capital. It was to buy foreign coin and offer bank accounts that came to be known as 'bank money'. The bank money was expressed and redeemable in gulden and therefore bore a premium over regular coins. A decree by the city that all bills of exchange with a value of 600 gulden or upwards needed to be settled through the transfer of deposits at the Bank of Amsterdam created immediate use of these accounts. The Bank of Amsterdam was from the beginning on created for providing the function of payments in bank money (Dunbar, 1902, ch. 8).

Eventually the Bank of Amsterdam started issuing credit in 1683, often against some collateral of foreign coins or bullion. This constituted a change in the transaction in which bank money was created and therefore also risked convertibility into specie. Disclosures in 1791 showed that over time credit was also secretly granted to the city with obligations of the state of Holland as collateral and the Bank of Amsterdam was bankrupt and needed to be saved (ibid.).

Bank Notes

The Swedish Riksbank, when it was established in 1656, had one department for exchange and one department for lending. Before it was taken over by the state in 1668, it was the first bank to issue bank notes in 1661. It did so as copper companies substituted 'copper notes' for coin in wages paid to miners and the copper notes became popular in use (Kindleberger, 1993, p. 52f).

Goldsmith receipts were used in England around the same time with the goldsmiths turning into bankers over time. But in England there were also scriveners[3] who preceded goldsmiths in lending and accepting deposits. Goldsmiths also lent to the government and received tally sticks

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[3] Scriveners are literate people performing all kinds of services regarding legal, court, and administrative affairs.

in return as a promise for future repayment, or a means of paying taxes (Kindleberger, 1993, p. 52ff).

Bagehot (1873, ch. 3) notes that in the spread of banking across countries the note issuance generally preceded deposit taking. He explains this with the active way bankers can use their notes as payments, but are passive in receiving deposits. Note issues are mainly begun by loans. Certain people of the public accumulate bank notes over time, face the risk of robbery, and then decide to replace them with deposit accounts. Thus, the use of bank notes decreases and the amount of deposits increase, which is visible in the bank balance sheet statistics of that time.

Banking Operations in T-accounts

The balance sheets presented as T-accounts throughout this paper are structured with the assets on the left side and the liabilities on the right side. Positive or negative signs indicate changes in balance sheet positions and no sign indicates no change. In most cases unaffected balance sheet items, such as equity, are not shown in the T-accounts. The balance sheets are chosen to effectively display financial transactions.

Balance Sheet 1 shows a local money changer exchanging foreign coins or bills of exchange against local coins, it is a simple asset switch.

Balance Sheet 1: Local Money Changer	
- Coins	
+ FX[4] Coins / FX Bills of Exchange	

Balance Sheet 2: Local Money Lender	
- Coins	
+ Loans	

Balance Sheet 2 shows a local money lender lending coins and accepting a promise of future repayment in return. Balance Sheet 3 shows the bank lending process by issuing bills of exchange. According to the entry 'Bill of Exchange' in the Oxford Dictionary of Finance and Banking (Law, 2014) these may also be called banker's acceptances when issued by a bank. A bank issuing bills of exchange for lending is akin to an overdraft by check, where it is predefined

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[4] FX is an abbreviation for 'foreign exchange'.

how much the debtor may borrow. The writing of the bill of exchange usually involves three parties, a buyer (borrower), a seller and a payer (bank). The buyer uses the bill of exchange to write it for the seller in exchange for goods and the seller can use the bill of exchange to receive money from the payer. The payer in return has a claim against the buyer (Megrah & Ryder, 1972, ch. 1). The bill of exchange issued by the bank ensures that the lending bank promises to pay a certain amount at a specified future point in time or on demand to the specified seller written on the bill.

In contrast to the operations in Balance Sheets 1 and 2, the lending operation using bills of exchange does not require a coin outflow for the lender at the time of lending. The borrower thus receives new purchasing power in the form of the bill of exchange, which he can use for payments.

Balance Sheet 3: Lending with Bills of Exchange

Coins	
+ Loans	**+ Bills of Exchange**

The difference between bank notes and bills of exchange is that the writing of bills of exchange usually involves three parties but the writing of bank notes only two.

Balance Sheet 4 shows the procedure of deposit banking with the bank issuing deposits or bank notes against domestic or foreign coins and also bullion. The newly created deposits or bank notes are redeemable into coins, but a coin outflow only occurs if such a redemption is requested. The bank notes or deposits denote a liability of the bank, an IOU[5].

Dunbar (1902, ch. 5) relates to the irrelevance of bank debt being denoted in bank notes or deposits, but that they are sometimes used for different types of transactions. The Bank of Amsterdam in its early years, as described above, is a good example for a deposit bank.

In Balance Sheet 5 it is shown that a bank extending a loan by crediting on a deposit account or issuing bank notes creates new money that can be used for transactions. Technically that is also the case in Balance Sheet 3 as bills of exchange were also commonly used for monetary

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[5] Abbreviation for 'I owe you', as a liability.

purposes. The depositing of bullion presented in Balance Sheet 4 further provides a means of 'liquefying' valuable things into money.

Balance Sheet 4: Deposit Banking	
Coins	
+ Bullion / FX Coins / Coins	+ Deposit / Notes

Balance Sheet 5: Bank Lending	
Coins	
+ Loan	+ Deposit / Notes

Kindleberger (1993, p. 54) refers to goldsmiths when lending rather inscribing deposits in their books than paying out in coin. These deposits and notes are all private IOUs that fulfill monetary functions.

It is interesting to recognize that while deposit banking is passive in granting deposit accounts or notes against coins, bank lending is active in creating new deposit accounts or notes without equivalent coin intake. Note also that the balance sheet in Balance Sheet 5 after lending appears as if a deposit had enabled the granting of a loan, even though that is not the case.

Balance Sheet 6: Bank Discounting	
Coins	
+ Bills of Exchange	+ Deposit / Notes

Balance Sheet 6 shows the later widely popular banking operation of discounting bills of exchange. The bank purchases an already existing bill of exchange not issued by itself, in contrast to Balance Sheet 3 in which the bank acts as one of the debtors of the bill of exchange and the bill of exchange becomes a liability of the bank.

As many bills of exchange had a fixed payment date in the future, banks offered to buy the bills at a discount such that holders of bills could change them into money before they matured. The discounting involved a payment of interest, which was forbidden by the church, and that is why it

developed fairly late. Nevertheless there were many practices of charging interest by disguising lending with foreign exchange transactions where exchange rates were involved (Kindleberger, 1993, p. 42). The discounting of bills is analogous to the case of the Bank of Amsterdam which at first secretly accepted obligations towards the state in exchange for providing deposits.

Adam Smith (1776, Book 2, ch. 2) already well understood the mechanisms of banks creating bank notes or deposits when lending or discounting bills of exchange. He called it a great benefit in facilitating trade, but also referred to the risk of bank runs, as notes and deposits exceeded banks' holdings of specie. He therefore advised banks to keep a certain amount of money to be prepared for redemptions.

The problem of bank runs gets even more difficult if bank notes are denominated in high value coin, as was the case with the Bank of Amsterdam.

In general the supply of IOUs fulfilling monetary functions helped overcome the decline in metallic money production in Europe in the Middle Ages, as well as the loss of wear and frequent debasements by the governments (Wray, 1990, p. 33f).

Central Banking

Kindleberger (1993, p. 54) explains that in England some goldsmiths acted as bankers for the other goldsmiths to facilitate clearing. This is an analogy to the bankers' bank. In seventeenth century England banks kept deposit accounts with each other in order to offset claims, but they eventually established a clearinghouse and later used Bank of England deposits for clearing (Kindleberger, 1933, p. 80). The Bank of England, as an example, was designated as a special bank in order to help finance public expenditures. It was to manage the government balances and in return received the monopoly of limited liability and to be the sole joint stock company to be permitted to issue bank notes (Bagehot, 1873, ch. 3). Balance Sheet 7 shows a simplified central bank balance sheet where the central bank could issue notes and deposits in order to purchase government debt.

Balance Sheet 7: Central Bank

Government Debt	**Deposits**
Gold Coins Silver Coins	**Notes**
Bullion Other Securities	

Regular banks regard the central bank as very creditworthy and prefer to hold their liquid assets in the form of central bank deposits, which are also used for interbank clearing. Notes and deposits were most of the time redeemable into specie. Bagehot (1873, ch. 2) puts special emphasis on the central bank as a lender of last resort and as an institution that should ensure stability of the financial system.

Fiat Money

Balance Sheet 8 shows the balance sheet of a central bank in a fiat monetary system. Gold and silver coins are no longer necessary and the new coins have a nominal value greatly exceeding their metallic content. The coins are written in brackets as coins are either issued by the central bank as a liability, or by the respective governments, which produce the coins and sell them at face value to the central bank against deposits and earn seigniorage (Seitz et al., 2012). Strictly speaking coins issued by the government are not a central bank liability, but a central bank asset.

Balance Sheet 8: Fiat Central Bank

Bullion	**Notes**
(Coins)	**(Coins)**
Government Debt	
Loans	**Deposits**
Other Securities	

The highest powered money in the form of deposits or notes is now simply an IOU, a central bank liability. Paradoxically, holding a central bank note states that the central bank 'owes' the holder money, although that person already has the money in his hands, because central bank notes in a fiat monetary system are not redeemable any further.

As notes and deposits originate from the fiat central bank, these monetary liabilities are created through lending, the purchase of securities and other assets, or other central bank expenditures such as salaries.

Maintaining reserves for the issued deposits and currency is no longer necessary for the central bank and corresponding regulations disappeared (Le Bourva, 1992).

Mehrling (2012) presents a hierarchy of money as IOUs that is worth displaying as a whole and shown in Table 1.

Table 1: The Hierarchy of Money in Balance Sheets by Perry Mehrling (2012)

Central Bank		Banking System		Private Sector	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Gold	**Currency**	**Currency**	**Deposits**	**Deposits** **Securities**	**Securities**

Table 1 shows the hierarchy of IOUs from right to left with private IOUs (Securities) at the bottom, bank IOUs (Deposits) on top and central bank IOUs (Currency) at the highest level. Mehrling puts gold on top of that as he argues that even in a fiat currency system gold could be used as a universal means of payment that is accepted across borders. In a similar representation, but in the form of a pyramid, also known as Exter's pyramid, Wray (2015, p. 78) emphasizes that the lower sector usually settles its IOU's using IOU's of the sector above. I.e. private sector liabilities are usually settled with payments using deposit accounts, and bank liabilities to other banks are usually settled using central bank IOUs.

In developed countries today cash as central bank IOUs in the form of notes is almost only used for marginal retail transactions, essentially as a conventional means of transferring money from one bank account to another. Central bank deposits are mostly relevant for interbank clearing, as households and firms are not entitled to have deposit accounts at the central bank. The central bank functions as a clearing house for the domestic banks. People have become very accustomed

to regular bank deposit accounts as money, although these accounts denote bank IOUs that are inferior to central bank IOUs due to credit risk. Central bank IOUs can be regarded as default risk-free, as the central bank IOU denominated in its domestic currency *is* the money that is defined to be paid to settle other IOUs.

How central banks and banks behave in such an environment is the object of investigation in the next chapter.

3. Endogenous Money

The previous chapter has outlined that in order to overcome difficulties in coin exchanges, shortages in precious metal supply, and to ease trade as well as government financing, credit instruments in the form of IOUs have come in place. These can take many forms, as bills of exchange, bank notes, bank deposits, hazelwood tally sticks, or others. The previous chapter also showed that in deposit banking local deposits or notes could be created as a consequence from demand for local money paid for with foreign coins, similar as in foreign exchange markets today.

This chapter takes the view that the quantity of IOUs that fulfill monetary functions is not exogenously determined by the government or central bank, but that it is endogenously determined within the economy. Although the formation of the modern banking system as described in the previous chapter would naturally suggest money as IOUs to be endogenous, there remains discussion if money has always been endogenous or not (Rochon & Rossi, 2013).

In the following it is argued that endogeneity is the case for central bank money as well as bank money and consequently it is discussed how deposit creation affects the funding costs for banks and central banks.

3.1. Endogenous Central Bank Money

Central banks have a monopoly power over central bank money, which is defined as their own liability in the form of deposits or cash. They determine the conditions under which central bank money is obtained by other members of the economy.

Based on Hicks (1974, p. 51), Lavoie (2001) determines between overdraft and asset-based economies. When banks are in debt to and have claims against the central bank and they can borrow at will against collateral, the monetary system is called 'overdraft system'. An overdraft system is characteristical of firms borrowing from banks at their line of credit instead of issuing securities. In asset-based economies banks hold government securities and sell them in order to make new loans, and firms issue securities in order to finance themselves.

Godley and Lavoie (2007, p. 374f) say that most firms and banks adjust their liquidity positions not by buying and selling assets, but by borrowing and thus changing their liabilities, a process called liability management. As this is not an asset-based adjustment mechanism they conclude that for the purpose of modelling it makes sense to stick to the overdraft system.

According to the Federal Reserve Bank of Chicago (1992) central banks commonly create central bank money by lending to domestic banks against collateral resulting in a balance sheet extension, which would be a common feature for an overdraft economy.

While exogenous central bank money theories such as the money multiplier model suggest the central bank to directly determine the quantity of central bank money, it is common monetary policy today to target short term interest rates and let the quantity of central bank money be determined by the loans demanded by the banks at that rate (Moore, 1988, ch. 5). The central bank behaves accommodative. Central banks may as well use the quantity of central bank money and buy and sell securities in order to meet a target interest rate in the interbank market for central bank money. This usually occurs together with a corridor for interest rates provided through deposit and lending facilities (Bindseil, 2014, ch. 4).

The offering of marginal lending facilities with which banks can borrow from the central bank outside of regular auctions displays the willingness of central banks in complying with banks' demand for loans (Furfine, 2003). Further if banks' increased demand for central bank money drives up interbank interest rates the central bank may comply by lending more central bank money in order to reduce the interest rates back to the target level.

The central bank money supply is then endogenously determined by bank demand which may also be affected by other factors than just the interest rate (Lavoie, 2005). In such a system the banks' potential borrowing from the central bank is restricted in quantity and quality of eligible collateral determined by the central bank (Bindseil, 2014, p. 22).

Lavoie (2001) notes that the central bank may also move government deposits between their account at the central bank and their accounts at commercial banks which results in central bank money being created or destroyed. This process is used by the Bank of Canada in order to fine-tune the interbank interest rate.

It should be noted that central banks using Quantitative Easing policies actively increase the central bank money supply in excess of fine-tuning of interbank interest rates, thus the question arises how a combination of exogenous and endogenous money policies should be assessed (Cavalieri, 2004, p. 67). Part of the central bank money remains endogenously determined and the emphasis here is to state that increased bank demand for central bank money is met with newly created reserves.

In Quantitative Easing policies central banks may still influence interbank interest rates while providing a surplus of central bank money to the banking system, through the use of the central bank deposit rate as a steering mechanism. The Federal Reserve System and the Bank of England pursue this method since 2009 (Bindseil, 2014, p. 53). Collateral requirements then become almost irrelevant as bank borrowing from the central bank becomes negligibly small.

3.2. Endogenous Bank Money

Theories on individual central bank behaviour concerning the practice of monetary policy can easily be confirmed or refuted, but the complexion of aggregating the behaviour of many banks in the banking system *requires theory*. Nevertheless we can infer from practitioners how individual banks behave and use known accounting identities to derive aggregate outcomes.

The central banker Ulrich Bindseil (2004, p. 23) notes that in credit departments of banks the decision to grant a loan never depends on the individual bank's current level of excess reserves[6]. He explains that banks can easily trade excess reserves in the money market and what matters is their opportunity cost. From the previous section we know that besides the money market, banks always face the possibility of borrowing from the central bank against collateral. This could explain why credit departments of banks do their lending regardless of the amount of central bank money they are holding.

The banks' willingness of extending loans could then be determined as the willingness of holding IOUs of certain firms or households, who in turn wish to obtain bank IOUs, namely deposits (Wray, 1990, p. 74). Richard Koo (2003, p. 3) cites a survey asking firms in Japan if their demands for bank credit are met and he comes to the conclusion that in normal times virtually all creditworthy firms are granted the loans they demand from banks. Post-Keynesian Economic Theory incorporates this accommodation of bank credit into its view of Endogenous Money Theory; bank money is then determined by creditworthy credit demand (Lavoie, 2009, p. 69).

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[6] Many central banks require banks to hold a minimum amount of central bank money in relation to their deposits, central bank money held in excess of this requirement is called 'excess reserves'.

3.3. Deposit Creation and Funding Costs for Banks and Central Banks

Balance Sheet 9 shows the central bank purchasing an asset or lending to banks, it represents a balance sheet extension of its own balance sheet. The central bank faces the cost of the central bank deposit rate on that proportion of its liabilities held as deposits by banks. It can choose the rate to pay on its own deposits.

<div align="center">

**Balance Sheet 9: Central Bank
Lending or Purchasing**

+ Asset / Loan / FX	+ Deposit

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Balance Sheet 10 depicts an aggregate balance sheet of all banks in a country, excluding the central bank, if any of them extends a loan or purchases an asset from a non-bank. The deposit expansion also occurs if any bank purchases foreign deposits from a foreign bank. It holds true if the cash holdings of the non-banks do not increase. It is important to understand that this is valid for the banking system as a whole and that the costs incurred for lending or purchasing assets is the deposit rate that banks offer to their customers.

<div align="center">

**Balance Sheet 10: Banking
System Lending to or
Purchasing from Non-Bank**

+ Asset / Loan / FX	+ Deposit

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However, these costs can be distributed differently between banks depending on which banks make loans and which banks are chosen by customers to keep their deposit accounts. While a bank when lending may create a deposit account, it is likely that the borrower intends to spend his money and send it by bank transfer to another entity. The distribution of the costs of lending then depend on if the receiver of the money has his deposit account at the lending bank or at another bank, which would require interbank settlement using central bank money.

In Balance Sheet 11 the balance sheet of a lending bank is presented that requires central bank money for interbank settlement as its borrower 'transfers' his deposits via bank transfer to a

customer at another bank. The terms in brackets after the assets indicate returns for holding assets or costs for liabilities.

Entry (**1**) is the process of a bank lending money or purchasing assets or foreign currency which results in a balance sheet expansion. In entry (**2**) the lending bank borrows central bank money (**CBM**) in the interbank market and then uses it for settlement with other banks in entry (**3**). The concluding end position results in settlement costs for the lending bank of the interbank interest rate r_{int}, but it receives the returns r_A of the new asset. Balance Sheet 12 displays the same transactions but from the view of the rest of the banking system without the lending bank.

Balance Sheet 11: Lending Bank borrows Central Bank Money from other Banks for Settlement

(1)	+ Asset / Loan / FX (r_A)	+ Deposit (r_{Dep})
(2)	+ CBM (r_{CBM})	+ Debt to Bank (r_{int})
(3)	- CBM (r_{CBM})	- Deposit (r_{Dep})
Σ	+ Asset / Loan / FX (r_A)	+ Debt to Bank (r_{int})

Balance Sheet 12: Banking System without the Lending Bank from Balance Sheet 11

(2)	- CBM (r_{CBM})	
(2)	+ Loan to Bank (r_{int})	
(3)	+ CBM (r_{CBM})	+ Deposit (r_{Dep})
Σ	+ Loan to Bank (r_{int})	+ Deposit (r_{Dep})

The end position shows that the rest of the banking system, seen in Balance Sheet 12, consequently receives the interbank interest rate r_{int}, but needs to pay the deposit rate r_{Dep}.

This situation is rather paradox as the interbank interest rate r_{int} commonly is below the deposit rate r_{Dep} paid by banks. The total costs for the banking system extending a loan is the deposit rate r_{Dep}, but this cost is shared between the lending bank paying r_{int} and the rest of the banks in the banking system having net payments of $r_{int} - r_{Dep}$.

In practice the share of costs paid by the lending bank depends on its market share in deposit holdings. Note that the financing cost of the deposit rate for the banking system as a whole is also true for banks purchasing assets such as stocks, bonds or foreign deposits.

On the other hand if the lending bank already had the central bank money before extending loans it would incur the opportunity cost of the rate it would have otherwise earned by lending the central bank money to another bank r_{int}, or keeping it deposited with the central bank and earning the according rate r_{CBM}.

4. Foreign Exchange Markets

Foreign exchange markets deal with the exchange of money in different units of account defined by the respective central banks of currency areas. Often derivatives are used to create exposure or hedge against foreign exchange rates and demand for these derivatives can move spot prices widely. The following presents the most important actors in foreign exchange markets, their settlement procedures, and common theories attempting to explain exchange rates.

4.1. Actors in Foreign Exchange Markets

Dealer Banks

The dominating actors in foreign exchange markets are dealer banks that have agreements with one another to provide bid and ask quotations upon demand (De Rosa, 2014, p. 12). In normal times they are therefore always willing to take either side of a trade while they can hedge correspondingly using derivatives. Dealer banks earn money through the spread between their bid and ask prices. They also provide services to their customers such that those can trade on margin against collateral (De Rosa, 2014, p. 283).

Speculators

Speculators often take the other side of the derivatives hedge by the dealer banks, as derivatives only distribute the risk to another entity. They are taking a foreign exchange exposure and hope to profit from it if the exchange rates move in the correct direction (Mehrling, 2013).

Non-Dealer Banks

Banks are occasionally involved in cross-border lending, borrowing or investing and in that case they don't like high volatility in foreign exchange rates. It could just as well be possible that one department of a bank is responsible for long-term lending and another is involved as a dealer in the foreign exchange market. Nevertheless the argument is that banks may have interest in foreign exchange transactions independently of their possible role as a dealer, but more as a portfolio decision (De Rosa, 2014, p. 3).

Central Banks

Central banks may intervene in foreign exchange markets in order to stabilize exchange rates or keep the domestic currency artificially low or high. Central banks also support the domestic dealer banks by taking foreign exchange exposure the latter may not wish to take. The central

bank is then seeking stability and hopes to ensure that foreign exchange demand resulting from scheduled payments is met (Mehrling, 2013). The targeting of interest rates as a monetary policy tool can heavily influence exchange rates as well and be used as an exchange rate influencing mechanism (Taylor, 2001).

Investors, Industry and Households, Government

Other actors relevant for foreign exchange markets are primarily driven by the wish to exchange given bank deposits into deposits denominated in another currency. Investors may wish to invest globally, households and firms or the government may have demand or supply of foreign exchange related to the trade of real goods, or borrowing from and lending money abroad.

4.2. Settlement

According to De Rosa (2014, p. 161) "settlement is the process of transferring funds to discharge the obligations of a foreign exchange transaction".

When two non-bank actors perform an exchange of different money they each require an account in their domestic currency area and in the foreign currency area. In effect a purchase of foreign currency reduces their deposits at their respective domestic accounts and increases their deposits at their respective foreign accounts. In the simplest case that is a swap of ownership in money and the exchange rate determines how much foreign deposits one receives in exchange for the domestic deposits. The respective national banking systems then perform an interbank settlement from one domestic bank account to another by means of exchanging central bank money between the involved banks.

Domestic settlement between banks is as a last step commonly done through their accounts with the domestic central bank (BIS, 2003). Sometimes private clearing mechanisms between banks such as CHIPS precede the settlement and only the remaining differences are cleared at the central bank (BIS, 2003). Central banks commonly only allow domestic banks to have an account with them, thus the access to 'electronic' central bank money is restricted to domestic banks. Nevertheless there are notable exceptions such as the European Central Bank that allows any bank in the European Economic Area to have an account with them if they fulfill certain requirements (BIS, 2003).

In order to settle foreign exchange transactions between banks each domestic bank usually has a deposit account at a foreign bank, a so-called 'nostro' account at a correspondent bank. E.g. a

London bank has a deposit account at a New York bank denominated in USD and the London bank will use this account to receive and perform payments in USD. The issue is that the London bank cannot have an account with the Federal Reserve System and therefore must be satisfied with a deposit account at a US-bank. The London bank may create a subsidiary in New York that has access to the Federal Reserve System in order to overcome this issue.

Chapter 6 elaborates the money endogeneity in foreign exchange markets due to the uses of different monies for settlement by different types if institutions and actors.

4.3. Common Theories of Foreign Exchange Rate Movements

There are many factors that influence actors' demands and supplies of money in the foreign exchange markets. These involve the demand for goods and services abroad as well as the demand for financial assets (Moss, 2014, ch. 7).

Further theories are based on interest rate differentials, expected inflation differentials and expected return differentials as well as the law of one price for financial assets with similar risks and returns (Ibbotson & Brinson, 1993, ch. 2). Some emphasize the relative price of the two stocks of money represented as the foreign exchange rate (Frenkel, 1976).

Purchasing power parity is a theory attempting to explain equilibrium exchange rates through the price level of goods in different economies. It is derived from the law of one price and assumes the absence of trade restraints; it suggests that exchange rates change in line with inflation differentials between countries (Ibbotson & Brinson, 1993, ch. 2).

Harvey (2012a) describes two popular models in neoclassical economics, a monetary approach and a portfolio balance approach. The monetary approach is based on purchasing power parity, flexible wages and prices and a stable demand for money. Accordingly the exchange rate is set by a quotient of the relative supply of money, as well as real incomes and factors determined by desired money balances to real incomes. The portfolio balance approach emphasizes the capital markets and demand for domestic and foreign money and financial securities. It states that profit maximizing investors keep their portfolios and only react to government policies or current account imbalances with current accounts being balanced in the long run.

A Post-Keynesian view presented by Harvey (2012b) puts forward that exchange rates are largely set by foreign exchange dealers since daily foreign exchange volumes exceed trade and portfolio investment flows by large multiples. These foreign exchange dealers have short-term

expectations largely determined by political, economic and monetary news, and medium term expectations determined by fundamentals such as the balance of payments, interest rate differentials, relative rates of inflation and growth rates.

Moss (2014, ch. 7) mentions that empirically different theories work better on different time horizons, he claims that interest rates are better at explaining short-term movements, inflation at medium-term movements and current account balances at longer-term movements. According to empirical analysis in Sweden done by Bohlin (2010) in the very long-term exchange rates may follow purchasing power parity.

The theories that include endogenous money as well as possible quantity changes due to foreign exchange are presented in the literature review in the next chapter.

5. Literature Review on Endogenous Money in Foreign Exchange Markets

Common equilibrium theories of flexible exchange rates assume that an increased demand for a foreign currency moves the foreign exchange rate until there is a corresponding equal amount of supply, i.e. demand of the foreign country for the domestic currency (Salvatore, 1995, p. 404). It is usually not considered that an increased demand for a currency can be met not only with a price increase, but also by an increase in the quantity of money. This chapter deals with those theories acknowledging an endogenous money creation due to foreign exchange transactions.

The review begins with literature on fixed exchange rate regimes and then outlines literature on the compensation principle, currency boards and balance of payments issues. The Money view follows and literature on banks' and central banks' demand for foreign exchange is presented as well as stock-flow consistent models referring to foreign exchange markets.

Money Endogeneity in Fixed Exchange Rate Regimes

There is common recognition of the assertion that central bank interventions during fixed exchange rate regimes result in central bank money being endogenously created or destroyed. The fixing of the exchange rate is done by buying or selling foreign currency with a corresponding central bank balance sheet expansion or contraction and central bank money being created or destroyed (Le Bourva, 1992).

In Neoclassical economics this is incorporated in the Mundell-Fleming model in which the central bank's monetary policy is regarded as ineffective, as the central bank needs to react to changes in foreign exchange demand and supply. It is argued that the central bank could try to increase the central bank money, but that such an increase would result in lower interest rates and an increase in output and imports together with a balance of payments deficit. The central bank must then sell foreign reserves and destroy central bank money to maintain the fixed exchange rate and this will lead back to the initial equilibrium (Lavoie, 2001).

As Neoclassical economic theory for the closed economy generally assumes the money supply to be set exogenously by the central bank with interest rates being endogenous, Lavoie (2001) calls the money endogeneity from the Mundell-Fleming model 'supply-led', in order to distinguish it from the 'demand-led' money endogeneity followed by Post-Keynesians. Lavoie differentiates as he argues that the Post-Keynesian money endogeneity derives from agents' demand for money,

but the Neoclassical endogeneity derives from autonomous factors keeping money demand constant (Lavoie, 2001).

The Compensation Principle

Post-Keynesians put much emphasis on the central bank's capabilities to reduce or increase the central bank money in order to offset increases or decreases thereof from the central bank's foreign exchange transactions, this is the 'compensation principle' (Lavoie, 2014, p. 462ff).

The compensation principle applies to central bank foreign exchange interventions in fixed exchange rate regimes and to 'managed floats' in which central banks intervene in otherwise flexible exchange rate regimes (Lavoie, 2014, p. 462).

Balance Sheet 13: Central Bank Compensating for Foreign Currency Purchases

	+/- FX	+/- CBM
(1)	-/+ Government Securities	-/+ CBM
(2)	-/+ Loans to Banks	-/+ CBM
(3)		+/- Government Deposits -/+ CBM
(4)		+/- Bonds -/+ CBM

Balance Sheet 14: Banking System with Government Deposits

(3)	-/+ CBM	-/+ Government Deposits

Balance Sheet 13 shows the compensation mechanisms the central bank can use against an increase or decrease in foreign exchange holdings. The sign before the forward slash shows the case in which the central bank purchases foreign exchange and the sign after the forward slash shows the case in which the central bank reduces its foreign exchange holdings.

In order to compensate, central banks can reduce or increase their claims against the government, entry (**1**), reduce or increase their claims against banks, entry (**2**), or they can shift government deposits between the government's account at the central bank and the government's accounts at commercial banks, entry (**3**) (Lavoie, 2001). The corresponding balance sheet of the banking system for the case of shifting government deposits is displayed in Balance Sheet 14. Lavoie

(2014, p. 472f) states that it is also possible for the central bank to issue bonds, entry (**4**), in order to reduce the central bank money supply, once these are issued, they could also be used for fine-tuning of the money supply.

Lavoie (2001) claims that these compensations often occur automatically e.g. banks in an overdraft financial system tend to reduce their debt vis-à-vis the central bank if they have excess central bank money, resulting in a destruction thereof. Banks in an asset based financial system may tend to buy government securities from their excess central bank money, and these government securities could be sold from the central bank resulting in the central bank money being destroyed again (Lavoie, 2001).

As long as a central bank directly controls interest rates, sterilization of its foreign exchange operations is necessary in order to maintain the target rate (Lavoie, 2014, p. 468). Lavoie (2001) provides historical examples of central bank foreign exchange interventions which were compensated and thus did not affect the size of the central bank balance sheet.

With the Post-Keynesian argument that balance of payments deficits do not necessarily result in a central bank money increase they can maintain their proposition that money is a demand-led endogenous variable (Lavoie, 2001). Thus, they can continue their proposition that the amount of central bank money is endogenously determined by bank demand, which in turn is determined by credit demand from households and firms (Le Bourva, 1992).

Central banks are limited in their capabilities of maintaining a fixed exchange rate regime if the demand for their currency is weak and they must sell foreign reserves to maintain the exchange rate. But the corresponding reduction in central bank money can always be compensated as a central bank can always increase the amount of central bank money by buying assets or lending to banks (Lavoie, 2001). Lavoie (2001) presents limits to the compensation principle in the case of high demand for the domestic currency when the central bank must buy foreign currency and central bank money is correspondingly created. The central bank could sell government securities or reduce their claims against the banks in order to compensate this increase, but will eventually run out of these assets to sell (Lavoie, 2001). This results in a negative correlation between foreign and domestic assets of the central bank (Lavoie, 2014, p. 474).

According to Lavoie (2014, p. 472f) there remains discussion if central banks are limited in their compensation abilities in the destruction of central bank money, even if the central bank runs out

of assets to sell, the central bank could issue debts, as mentioned above, but this raises the question of interested investors and interest rate differentials. It is important to research these limits as the exchange rate can be seen as an additional policy instrument to the setting of interest rates. Examples are the case of the Chinese and some other Asian central banks accumulating foreign exchange reserves in recent decades.

In the end Lavoie (2001, p. 235f) concludes that the compensation thesis holds for fixed and flexible exchange rate regimes. The central bank has a choice of fixing the interest rate. It may e.g. increase the interest rate in order to increase the opportunity cost of outgoing money and attract foreign investors, but at the same time purchase foreign currency to maintain the exchange rate level and compensate in order to keep the domestic central bank money supply constant.

Currency Boards

Lovronovic et al. (2011, p. 22f) explain that in countries with currency boards the central bank decides to hold its assets in the form of foreign exchange reserves and keep the amount of central bank money tied to these reserves. These countries try to maintain fixed exchange rates and convertibility by buying and selling foreign currency. Forces in the foreign exchange markets therefore result in increases and decreases in the domestic central bank money without any compensation. The primary central bank money creation process is then exogenously determined by the demand for the domestic currency.

Pure Float and the Balance of Payments

Robert Triffin (1966a, ch. 1) describes that in an exchange rate system of purely floating exchange rates one is almost prone to ignore balance of payments problems since the balance of payments always balance. He goes on that the balance of payments must balance through double-entry bookkeeping procedures. But still they pose an issue as he explains that a country cannot possibly run deficits on the current account if there is no external financing to cover them.

Cencini (1995, p. 151) explains that this concept is highly relevant to Triffin when he examines the role of the US dollar during the gold exchange standard, as the USA pursued large current account deficits which were paid with dollars that remained in the USA, but now had foreign owners. According to Cencini (1995, p. 151) Triffin argued that even in a system without convertibility to gold this would pose a problem. Triffin (1966b) was well aware that the purchase of external assets by foreign banking systems would result in an increased money

supply in those countries, which is why he differentiated between external and internal origins of changes of the money supply.

Jacques Rueff (1963 p. 324; Rueff, 1980, p. 302, as cited in Cencini, 1995, p. 152) goes further and speaks of a duplication of dollars in the sense that received dollars can only be deposited in US banks, but that foreign banks as owners of these deposits need to provide Eurodollar accounts to their customers for them to have US dollars. The claims to the US dollars are therefore doubled. Cencini (1995, p. 153) repeats that the duplication of dollars is a consequence of the fact that currencies cannot leave their national banking systems.

According to Lovrinovic et al. (2011, p. 6), if the primary money creation channel is the purchase of foreign currency then this would result in a transformation of foreign purchasing power into domestic purchasing power. While in the very short term this could be true, one could argue that foreign reserves are mostly held in the form of securities such as government bonds, thus allowing for a recirculation of the obtained foreign currency.

The Money View

The money view is a concept by Perry Mehrling (2013) that views foreign exchange rates not primarily as relations between prices of goods or assets, but as a relative price of money determined in dealer markets by the order flow. Mehrling builds his analysis on a paper by Jack Treynor (1987) in which dealers post buy and sell prices and through market activity build up or draw down inventories of securities. The dealers then shift their buy and sell prices according to their security buildup and in relation to prices at which possible outside buyers such as value investors would step in. Mehrling (2013) applies this concept to the foreign exchange market and shows that the foreign exchange dealer system often facilitates settlement by creating credit. Further the central bank acts as a dealer of last resort in order to maintain stability in the payment system. This is relevant in the payment interactions between surplus and deficit countries. If at the end of the day net payments remain to be settled, they are taken over by foreign exchange dealers or in the last resort by the central bank. Ultimately deficit countries are limited in their foreign purchases if they cannot acquire the necessary dollars to settle the transactions. If they cannot do so, some agreed purchases may need to be reversed.

Dealers are willing to provide dollars to deficit countries because they can hedge their currency exposure using derivatives such as a forward contract, but eventually this just distributes the risk

to another risk taker. Mehrling puts much emphasis on a hierarchy of money with the US-dollar at the top and that the dealer system is differently available for different currencies with differently strong central banks. This is visible in prices that reflect liquidity premiums, as e.g. derivatives are not readily available for all currency pairs.

In the pricing of exchange rates Mehrling (2013) notes that order flow may push prices for different reasons than fundamentals.

Foreign Exchange Demand by Banks and Central Banks

Banks or central banks may wish to hold foreign reserves permanently irrespective of their service to customers. Rodrik (2006) notes that developing countries have accumulated losses due to their increased foreign exchange holdings since the 1990s and examines why these foreign securities are held nonetheless. He concludes that the greater liquidity provided through the holdings of foreign reserves reduces the likelihood of financial crises, which is something of interest to many Asian countries after the Asian financial crises. Mendoza (2003) names the reason for Asian foreign exchange holdings a self insurance motivation against financial crises.

Post-Keynesians such as Sheila C. Dow (1999) emphasize liquidity preference as a reason for holding foreign reserves. Liquidity preference is the demand for a tradable asset with stable value and the motives of holding it can be the transactions motive, speculative motive or precautionary motive. In cases such as falling currencies in relation to others it may be reasonable to hold foreign reserves for liquidity preference, which may be termed international liquidity preference.

Dow says (1999) this international liquidity preference may also hold for monetary authorities keeping liquid assets for clearing imbalances between themselves. Assets held for liquidity preference should be short term in nature and in a stable currency, but may also be assets such as gold.

McKinnon (1979, p. 10ff) confirms that foreign exchange dealer banks have a demand for working balances that they keep with their correspondent banks abroad, as they want to maintain flexibility. This is important as they may be exploited by other players in the market if they rely too much on the flexibility of borrowing foreign currency by other dealer banks, these may adjust their selling prices if they can make a quick profit. Additionally interbank contracts occur on a wholesale level with large contract sizes such that there is always a slight mismatch between foreign reserves held and transactions done for customers.

Although not taking into account the endogenous nature of banks buying foreign exchange, some authors (Goodman, 1982) emphasize a portfolio approach in which banks in their asset and liability management may wish to hold foreign reserves. Palley (1992) developed a model in which bank choices regarding their assets also affect the money supply, but not through the mechanisms of a balance sheet extension.

Stock-Flow Consistent Models

Stock-flow consistent modelling provides a solid base for modelling the money creation and destruction process as well as the monetary flows through the economy. It is because all monetary and physical stocks and flows between every included sector need to be accounted for (Lavoie, 2009, p. 74). A macroeconomic open economy model suggested by Godley and Lavoie (2007, ch. 12), built on Godley (1999) incorporates the mechanisms by which a central bank or bank purchase of securities, foreign or domestic, results in an increase in the domestic money supply. They also suggest modifications concerning the determination of exchange rates, e.g. interest rate differentials, investor expectations or endogenous exchange rates. But the focus remains on endogenous government bill issues, which eventually are bought by central banks with newly printed money. Although in the described model the increased money supply does have an effect on the economy through government expenditures and possibly later through portfolio channels on exchange rates, the supply and demand conditions on the foreign exchange market are not examined.

Summary

It has been long established as common knowledge that central bank money is created when central banks intervene in foreign exchange markets. Post-Keynesians using the compensation thesis argue that this creation can be compensated by reducing the central bank money through other positions on the central bank balance sheet. With money being unable to leave its currency area there is some awareness through the existence of the Eurodollar market, that deposits may be duplicated abroad. The Money view provides a striking insight into foreign exchange dealer markets and money creation, but it only has a short term time horizon. In the long-run banks may have certain incentives for holding foreign assets, but the effect that has on the money supply and economy is virtually un-researched. Stock-flow consistent models show understanding of the interlinkage of the complete money creation process and the economy and provide an excellent base of investigating the endogenous money creation through foreign exchange markets.

6. Foreign Exchange Markets and Endogenous Money

This chapter describes the endogenous money creation and destruction in foreign exchange markets. It begins with Section 6.1 explaining the different monies used by different sectors for payments depending on the counterparty, currency and access to types of money. From this four general rules of money creation in foreign exchange transactions are derived in Section 6.2. Section 6.3 provides detailed accounts of money creation and destruction by transactions between different countries and their sectors. In Section 6.4 the relevance of the intention of using the acquired foreign currency is discussed, as the use can offset the effect of money creation. Section 6.5 discusses limits and exclusions from the analysis and Section 6.6 provides implications for the understanding of exchange rates.

While central bank foreign exchange interventions are fairly well researched also with respect to bank money creation (e.g. Federal Reserve Bank of Chicago, 1999) this chapter innovates with a complete picture of money creation and destruction due to bank or central bank foreign exchange involvement emphasizing the relevance of the involved counterparties.

6.1. Receiving and Sending Domestic and Foreign Money

Different sectors use different monies to settle their transactions and for some the type of money used depends on the currency in which the transaction is to be settled. Balance Sheet 15 shows the non-bank sector which performs payments by changes in its bank money deposit accounts BM, that it has with a foreign or domestic bank. In the most common case presented here, domestic deposit accounts are denominated in the domestic currency (D) and foreign deposit accounts are accounts at a bank in a foreign currency area and denominated in that foreign currency (F).

Balance Sheet 15: Different Monies used by the Non-Bank Sector	
BM_D	$Equity$
BM_F	

Balance Sheet 16: Different Monies used by the Banking System	
CBM_D	$Equity$
BM_F	BM_D

Balance Sheet 16 shows the balance sheet of the banking system of a country in which banks perform payments with other domestic banks in domestic central bank money CBM_D, perform

payments in foreign currency with their deposit accounts at foreign banks BM_F, and perform payments in domestic currency with domestic non-banks and foreign banks through their liabilities, namely domestic deposit accounts BM_D.

In Balance Sheet 17 the central bank balance sheet is displayed, in which the central bank can receive foreign currency in the form of central bank money CBM_F through its account at other central banks and can perform payments in domestic currency through its own liability, domestic central bank money CBM_D.

**Balance Sheet 17: Different
Monies used by the Central Bank**

CBM_F	$Equity$
$Securities$	CBM_D

Balance Sheets 15 to 17 hint at the crucial reason for money creation through fairly common transactions. The reason is the financial interaction between sectors, domestic and foreign, that use different monies, which results in bank and central bank balance sheet expansions or contractions with money being created or destroyed.

It is the change of ownership of a higher-powered money to an entity that does not have a possibility accessing this type of money resulting in an intermediary receiving this higher-powered money and providing a lower type of money to the initial receiver.

6.2. Rules for Money Creation in Foreign Exchange Transactions

Foreign exchange markets involve the purchase or sale of a currency and therefore incomes and expenses that would affect equity can be excluded.

Domestic central bank money CBM_D is created through balance sheet expansion and destroyed through contraction. This occurs when a central bank purchases or sells foreign currency against its domestic currency, visible in Balance Sheet 18. Note that the central bank receives foreign central bank money CBM_F irrespective of the counterparty involved in the foreign exchange transaction.

Balance Sheet 18: Central Bank Creating Central Bank Money			Balance Sheet 19: Banking System Creating Bank Money	
$+/- CBM_F$	$+/- CBM_D$	(**1**)	$+/-$ CBM	$+/- BM_D$
		(**2**)	$+/- BM_F$	$+/- BM_D$

Balance Sheet 19 displays the two cases in which bank money can be created or respectively destroyed. In case (**1**) the balance sheet expansion or contraction occurs with an increase or reduction in domestic central bank money held by the banking system and in case (**2**) the expansion or contraction occurs with an increase or reduction of foreign currency held by the banking system.

The following four rules describe all the cases in which bank money or central bank money is created or destroyed.

Four Rules for Money Creation in Foreign Exchange Transactions

(**1**) Domestic central bank money is *created* when the domestic central bank *purchases* foreign currency and *pays* with domestic central bank money CBM_D, with a corresponding balance sheet *expansion*.

(**2**) Domestic central bank money is *destroyed* when the domestic central bank *sells* foreign currency and *receives* domestic central bank money CBM_D, with a corresponding balance sheet *contraction*.

(**3**) Bank money in a country A, BM_A, is *created* if a sector that has access to central bank accounts in country A *pays* currency A to a foreign or domestic sector that does not have an account at the central bank in country A.

(**4**) Bank money in a country A, BM_A, is *destroyed* if a sector that has access to central bank accounts in country A *receives* currency A from a foreign or domestic sector that does not have an account at the central bank in country A.

In rules three and four it is implied that a domestic central bank has access to its own accounts.

6.3. Cases of Money Creation and Destruction at Foreign Exchange Settlement

This section displays all possible combinations of sectors in foreign exchange transactions and the corresponding money creation or destruction at settlement.

Buying Foreign Currency from the Country it is issued

The combinations of sectors involved when two countries buy each other's currency are displayed in Table 2. The sectors are chosen to be from hypothetical country A or B. Each sector from a country is the seller of his home currency and a buyer of foreign currency. The process of buying foreign currency and spending it is separated into two different transactions, as money is created or destroyed differently. Table 2 only shows the money creation at settlement of the foreign exchange transaction, for the spending of foreign currency see Section 6.4.

Table 2: Money Creation at Purchase of Foreign Currency from a Foreign Sector

		Country B		
		Central Bank	Banking System	Non-Bank Sector
Country A	Central Bank	$+CBM_A$ (2.1) $\qquad +CBM_B$	$+CBM_A$ $+BM_A$ (2.2)	$+CBM_A$ $+BM_A$ (2.3) $\qquad -BM_B$
	Banking System	$+CBM_B$ (2.4) $\qquad +BM_B$	$+BM_A$ (2.5) $\qquad +BM_B$	$+BM_A$ (2.6)
	Non-Bank Sector	$-BM_A$ $+CBM_B$ (2.7) $\qquad +BM_B$	(2.8) $\qquad +BM_B$	(2.9)

Using the above mentioned four rules and applying them to both currencies Table 2 can be constructed. Nevertheless the detailed balance sheets of the sectors involved are presented in Appendix A1. It is visible in cases 2.1, 2.2, 2.3, 2.4 and 2.7 that as central banks purchase foreign currency their respective central bank money is created. Further if a sector receives payment from the central bank, but does not have an account with it, then also bank money is created. In cases 2.3 and 2.7 bank money is destroyed, as a central bank receives foreign currency from a sector that does not have access to the respective central banks, applying rule number four. Applying

rule number three in case 2.5 results in bank money being created in both countries. Cases 2.6 and 2.8 present a one-sided bank money creation. In case 2.9 no money is created or destroyed. Cases 2.4, 2.7 and 2.8 are essentially mirror cases to 2.2, 2.3 and 2.6.

When banks act as intermediaries for non-banks it may happen that banks at first purchase foreign currency, which could display case 2.2, but then sell the foreign deposits to their customers, which would result in case 2.3. The intermediation would not affect the end result of money creation in case 2.3.

Selling of Foreign Currency to the Respective Country

In the case of a later reversal of the transaction in which a sector from country A may sell the foreign currency back to a sector from country B and vice versa, the money creation or destruction can also be described using Table 2, except with opposite signs for each entry.

The results are true for the sectors irrespective of individual actors, such that e.g. one bank in country A could purchase foreign currency and another bank in country A could later sell foreign currency to a sector in country B.

Using Table 2 one could then determine the money supply changes if e.g. a bank from country A purchases foreign currency from a bank in country B, case 2.5, and later sells it to a non-bank in country B against currency from country A, case 2.6 with an opposite sign. The process would result in bank money being created in country A and B, but the bank money in country A being destroyed again with the end result of a bank money increase in country B.

Table 2 thus allows extensive analysis of money creation and destruction due to foreign exchange transactions between two countries.

Purchasing Foreign Currency from a Domestic Sector

Another series of cases in foreign exchange markets that are not represented in Table 2 is when a domestic sector purchases foreign currency from another sector in the same country that already holds foreign currency.

This case is presented in Table 3, with the domestic money creation properties as if any other asset was bought or sold between the sectors. But as foreign currency from country B is being bought and sold there may also be an effect on the money supply in country B.

Table 3: Money Creation at Purchase of Foreign Currency from a Domestic Sector

Country A, Seller of FX

		Central Bank	Banking System	Non-Bank Sector
Country A, Buyer of FX	Central Bank	(3.1)	$+CBM_A$ (3.2) $\quad -BM_B$	$+CBM_A$ $+BM_A$ (3.3) $\quad -BM_B$
	Banking System	$-CBM_A$ (3.4) $\quad +BM_B$	(3.5)	$+BM_A$ (3.6)
	Non-Bank Sector	$-CBM_A$ $-BM_A$ (3.7) $\quad +BM_B$	$-BM_A$ (3.8)	(3.9)

Table 3 is also constructed using the four rules from section 6.2 and the detailed balance sheets are presented in Appendix A2. In cases 3.2, 3.3, 3.4 and 3.7 rules three and four apply in that bank money is created or destroyed in country B. The central bank money and bank money creation in these cases is fairly similar to Table 2 with the exception that the domestic banking system has access to central bank money. Cases 3.6 and 3.8 show that when domestic banks buy or sell assets to non-banks bank money is being created or destroyed.

Note that the diagonal cases 3.5 and 3.9 show that financial transactions between similar domestic sectors do not result in a change in money supply. Case 3.1 is non-existent as countries usually only have one central bank and one currency.

Purchasing Foreign Currency from, or selling to, a Sector of a Third Country

Further the series of cases in which a third country C is involved as a buyer or seller of currency B to country A is displayed, such that an international foreign exchange transaction occurs between two countries with a currency of a third country involved. Table 4 shows the cases of sectors from country A purchasing currency B from a sector in country C, using its domestic currency A for payment.

Table 4: Money Creation at Purchase of Foreign Currency from a Third Country

Country C, Seller of Currency B

		Central Bank	Banking System	Non-Bank Sector
Country A, Buyer of Currency B	Central Bank	$+CBM_A$ (4.1)	$+CBM_A$ $+BM_A$ (4.2)　　　$-BM_B$	$+CBM_A$ $+BM_A$ (4.3)　　　$-BM_B$
	Banking System	(4.4)　　$+BM_B$	$+BM_A$ (4.5)	$+BM_A$ (4.6)
	Non-Bank Sector	$-BM_A$ (4.7)　　$+BM_B$	(4.8)	(4.9)

The four rules should be applied to all currencies involved. However, as no sector pays with or receives currency C, there is no change in money supply for currency C. For each sector in country C the selling of foreign currency against another foreign currency simply presents an asset switch. The money supply in country B is only affected if the change of ownership has a central bank involved, rules one and two apply. The money creation in country A due to purchase of foreign currency is the same as in Table 2. For further details see Appendix A3.

Table 4 with a reversal in signs presents the opposite case in which country A sells currency B against its domestic currency A from country C.

Two Countries exchanging one Foreign Currency against another Foreign Currency

In Table 4 country A paid with its domestic currency in order to obtain foreign currency B from country C. The last series of cases is presented in Table 5, in which both involved countries receive and pay with a currency other than their own.

As only currencies B and D are involved only their money supplies can change. The money supply only changes if a central bank is involved. It changes as central bank ownership is changed in a foreign currency to a non-central bank that keeps its foreign currency at foreign deposit accounts in the form of bank money. See Appendix A4 for detailed balance sheets.

Table 5: Money Creation at Purchase and Simultaneous Sale of Currency other than the Domestic Currency

Country C, Seller of Currency B, Buyer of Currency D

		Central Bank	Banking System	Non-bank Sector
Country A, Buyer of Currency B, Seller of Currency D	Central Bank	(5.1)	$-BM_B$ (5.2) $+BM_D$	$-BM_B$ (5.3) $+BM_D$
	Banking System	$+BM_B$ (5.4) $-BM_D$	(5.5)	(5.6)
	Non-bank Sector	$+BM_B$ (5.7) $-BM_D$	(5.8)	(5.9)

The last set of cases is that a country A would buy and sell two foreign currencies with another sector in country A. However, the corresponding table does not need to be displayed as it is the same as Table 5. If one replaces country C in Table 5 with country A the resulting table remains with the same results of money creation and destruction.

6.4. Money Creation and Destruction from Spending Foreign Currency

The previous section explains that there are many cases of money creation and destruction occurring purely at the settlement process of foreign exchange transactions. Nevertheless foreign currency is usually bought in order to spend. Even for central banks that do not wish to spend the foreign currency on goods it is commonly advisable to purchase government bonds of the foreign country in order to obtain a, usually, positive yield. In terms of macroeconomic consequences it is much more important to see the total effect of foreign currency transactions not only involving settlement, but also the purchase of securities, as this alters the result of total money creation and destruction. Table 6 displays the effect of sectors from country A using their previously acquired foreign currency from country B to purchase financial securities from sectors in country B, the details are in Appendix A5. The money creation and destruction displayed in Table 6 only involves the settlement at purchase of already existing securities.

Table 6: Money Creation at Purchase of Foreign Securities using Foreign Currency

Country B, Seller of Security

<table>
<tr><td rowspan="8" style="writing-mode:vertical-lr">Country A, Buyer of Security</td><td></td><td>Central Bank</td><td>Banking System</td><td>Non-bank Sector</td></tr>
<tr><td>Central Bank</td><td>(6.1) $-CBM_B$</td><td>(6.2)</td><td>(6.3) $+BM_B$</td></tr>
<tr><td>Banking System</td><td>$-CBM_B$
(6.4) $-BM_B$</td><td>(6.5) $-BM_B$</td><td>(6.6)</td></tr>
<tr><td>Non-bank Sector</td><td>$-CBM_B$
(6.7) $-BM_B$</td><td>(6.8) $-BM_B$</td><td>(6.9)</td></tr>
</table>

Rules one and two mentioned in Section 6.2 can be generalized to also include the purchase and sale of other assets than foreign currency, but only if the method of payment is domestic central bank money. Using this, as well as rules three and four, Table 6 can be constructed. As only currency B is used for payments against securities, only currency B can exhibit changes in money supply.

The visible changes in bank money and central bank money from the sale of a security against currency B are the exact opposite of the changes visible in Table 2. This is because Table 2 shows sectors from country B purchasing a foreign asset from sectors in country A and Table 6 shows a sale of assets to foreign sectors.

Combining cases of foreign exchange settlement from Table 2 with Table 6 shows that much of the created money may be destroyed again as soon as it is spent. It depends on the counterparty involved in each case. Further one must investigate both sides of the foreign exchange transaction, as it could happen, that country A and country B purchase foreign currency in order to spend it and possibly buy securities. Table 6 then needs to be applied to both countries. Examples are provided to highlight relevant combinations of foreign currency transactions and subsequent purchases of securities.

Example 1: Currency Intervention by a Central Bank and the Compensation Principle

If a central bank from country A purchases foreign currency from a foreign non-bank, case 2.3, then CBM_A and BM_A are created and BM_B is destroyed. If the central bank then purchases foreign securities from non-banks using the foreign currency, case 6.3, the previously destroyed bank money BM_B is created again. The result would remain with only new bank money and central bank money, however, the question arises how the non-bank that bought currency A from case 2.3 spends its newly acquired currency. If it buys securities from the foreign non-bank sector there is no further effect on the money supply, this is the most probable case. But if it happens that the non-bank sector from country B buys securities from central bank A, then also CBM_A and BM_A are destroyed, case 6.7 from country B's point of view, with the end result of all created money being compensated.

Thus, if the central bank from country A intervenes in the currency market by purchasing foreign currency it can sell other securities such as domestic government bonds in order to compensate for the creation in domestic central bank money and bank money. Nevertheless this only works smoothly if it is the domestic or foreign non-bank sector that buys the government securities, otherwise it may happen that only the central bank money is compensated and not the bank money.

The choice of the compensating mechanism and counterparty are therefore relevant for central banks intervening in foreign exchange markets. Otherwise new domestic bank money may remain as an intended or unintended consequence of foreign exchange intervention. Automatic compensating mechanisms mentioned in Section 5, such as banks using their additional central bank money to reduce their potential debt vis-à-vis the central bank, may not suffice to also compensate for the increase in domestic bank money.

Example 2: Banks purchase Foreign Currency and invest in Securities

When banks purchase foreign currency and pay with their domestic currency, case 2.5, bank money is created in both countries. If each of the banking sectors then use their foreign currency to buy securities from the non-bank sectors, case 6.6, the money creation is unaltered, the end result remains with bank money created in both countries.

When only one banking sector purchases foreign currency from the foreign non-bank sector, case 2.6, and both use their currency to buy securities from the non-bank sectors, cases 6.6 and 6.9,

then only bank money is created in the country where the banking system bought foreign currency.

The bank money created by banks being active in foreign currency markets or foreign securities is usually not subject to compensation by the domestic central bank. Thus there could be lasting macroeconomic effects through the money supply expansion from certain foreign exchange transactions. In turn these money supply increases may also affect the demand for foreign currency from the non-bank sector in the country in which the money supply increased.

Sections 6.3 and 6.4 provide a great number of possible combinations resulting in bank money and central bank money being created or destroyed subject to the patterns described in Section 6.2.

6.5. Exclusions and Further Issues

Cash

The explored cases present the most common of foreign exchange transactions and settlements with some minor issues excluded. One excluded part is the use of cash, which in terms of transaction volume is minuscule in comparison to electronic foreign exchange markets. In addition foreign exchange transactions with cash on both sides obviously exclude the creation of money. The combination of foreign exchange transactions with cash and bank money is excluded as there are separate dynamics in money creation from depositing and withdrawing cash, namely depositing cash creates bank money and withdrawing it destroys bank money.

Newly Issued Securities

The securities used in Section 6.4 are already existing securities that change ownership. One can easily adjust to newly issued securities and the results change only slightly with equity and debt being affected.

Central Bank Accounts

In the above analysis it is assumed that only domestic banks and foreign central banks have access to central bank accounts, this was already questioned in Section 4.2, but it should be mentioned that central banks also allow international organizations such as the International Monetary Fund to have accounts with them and some central banks even allow employee deposit accounts (BIS 2003).

Currency Areas, Currency Substitution, Local and International Currencies

The analysis assumes that each country has its own currency, this is of course far from the truth given the euro area as well as countries that decide to use a foreign currency such as Ecuador using the US dollar or Liechtenstein using the Swiss Franc. Additionally, in reality there are a range of local currencies within countries such as the 'WIR Franc' in Switzerland, but also international currencies such as Bitcoin or Special Drawing Rights from the International Monetary Fund.

Bank Subsidiary in other Country

The foreign bank that a domestic bank uses for keeping its foreign currency denominated deposit accounts may just as well be a local subsidiary of the domestic bank. This allows the domestic bank indirect access to foreign central bank money as well as indirect access to the foreign central bank's credit facility. Technically in such a case the receipt of foreign currency for the domestic bank does not necessarily take the form of bank money, as the group internal liability could have different terms than a regular deposit account. More precise the subsidiary bank may receive from interbank clearing at foreign exchange settlements central bank money as a new asset, but will record a new liability not in the form of bank money, but as a 'debt to parent company'.

Nevertheless, the domestic bank will probably buy foreign currency in order to purchase securities, with a corresponding interbank settlement resulting in the destruction of the mentioned intra-group liability and creation of bank money at a different bank.

6.6. Implications for Exchange Rates and the Money Supply

Demand and Supply

The coincidence that increased demand for foreign currency may be met with newly created bank money or central bank money is relevant for the movement of foreign exchange rates. For the case of central bank interventions the foreign exchange rate may be fixed in one or both directions as it is unfeasible for investors to e.g. pay a higher price for foreign currency if they can buy it for cheaper from the central bank. The same applies for potential selling at lower prices than the central bank is offering to buy. The central bank simply fulfills all demand with no price effect.

For bank money the issue becomes more difficult. If the total demand for a currency is partially met by increases in quantity rather than price, how does that affect exchange rates? One could argue that the accommodation of demand through quantity reduces exchange rate movements in comparison to the case without. With dealer banks constantly offering buy and sell prices the demand of a large investor could at first be completely met such that the demand creates its own supply. But this could prove to be a dilemma if an increased demand for foreign currency is met by the respective banks in the short term as a financial service, but in the long-run these banks may want to sell their foreign currency to obtain domestic currency. If the whole banking system of a country is a seller of foreign currency against domestic currency it may be hard to find a buyer resulting in a movement of foreign exchange rates until a buyer is found. The exchange rate movement may thus occur lagged in comparison to the case without available dealer banks. In smaller countries the central bank may step in as a buyer if the potential currency move is too large.

Feedback Effects

The change in money supply may also exhibit feedback effects such that an increase in central bank money could influence banks' demand for foreign currency. The same applies to additional bank money that could increase foreign currency demand by the non-bank sector. Reductions in money supply could reduce the demand for foreign currency. Feedback effects could differ in the short- or long-run, but they could be relevant in the light of portfolio decisions and the creation of new purchasing power.

Money Supply

The money supply changes due to foreign exchange transactions depending on the actors involved with bank money and central bank money created or destroyed. For economies it is thus very relevant how foreign currency is obtained and how it is used, as different alternatives affect the money supply differently and consequentially affect the purchasing power available for the economy in the form of money.

7. Empirical Evidence of Endogenous Money in Foreign Exchange Markets

Empirical evidence for the money endogeneity is presented in the form of an analysis of the balance sheet of the Swedish banking system. Endogenous central bank money has been researched fairly well, which is why the focus here remains on bank money. The data is described in Section 7.1 and the Swedish banking system's balance sheet is observed in Section 7.2. Section 7.3 performs an analysis of the different balance sheet positions on how they covariate and Section 7.4 derives what can be concluded concerning empirical money endogeneity.

7.1. Data

The dataset is from Statistics Sweden with the entry 'Monetary Financial Institutions (MFI), assets and liabilities by MFI, item and currency' of which the subgroup of only banks is selected. The data consists of monthly balance sheet positions from January 1998 until December 2015 and each balance sheet position is broken down into positions denominated in domestic or foreign currency. A detailed account of the selected data for replication can be found in Appendix B1.

7.2. The Swedish Banking System Balance Sheet

Table 7 displays the balance sheet of the Swedish banking system at the end of December 2015. Assets and liabilities are presented pairwise and it is indicated if the assets and liabilities are denominated in foreign currency, FX, or domestic currency, SEK.

Table 7: Swedish Banking System Balance Sheet at 31.12.2015 in mio. SEK

Positions	Assets	Liabilities	Difference
Loans / Deposits in SEK	3.755.788	3.230.815	524.973
Securities / Debt in SEK	1.450.389	1.449.318	1.071
Loans / Deposits in FX	2.371.664	1.473.007	898.657
Securities / Debt in FX	1.351.963	2.552.005	-1.200.042
Equity	0	224.659	-224.659
∑	8.929.803	8.929.803	0

Datasource: Statistics Sweden, 2016

The column 'Difference' shows cross-financing between asset categories, e.g. if the banking system holds much more loans in foreign currency than deposits in foreign currency, the difference must be financed through other types of liabilities, in this case most likely foreign debt securities.

The sought-after effect of endogenous money *creation* is missing in Table 7, as one would expect deposits in SEK to exceed loans in SEK and foreign currency assets to exceed foreign currency liabilities. This would indicate that the banking system purchases foreign currency denominated assets by paying with domestic deposits. However, exactly the opposite is visible, loans in SEK exceed deposits in SEK and debt in foreign currency exceeds assets in foreign currency. Does that indicate that the Swedish banking system borrows foreign currency in order to finance domestic loans in SEK? Appendix B2 discusses that possibility, but largely rejects it. Instead the reason for the composition of this balance sheet is to be found in endogenous money *destruction* due to foreign exchange transactions.

Balance Sheet 20: Banking System Borrows Foreign Currency for Customers			**Balance Sheet 21: Non-Bank Sector buys Foreign Currency from Domestic Banking Sector**	
(1)	$+BM_{FX}$	$+Debt_{FX}$	**(2)**	$-BM_{SEK}$	
(2)	$-BM_{FX}$	$-BM_{SEK}$	**(2)**	$+BM_{FX}$	
Σ		$+Debt_{FX}$	**(3)**	$-BM_{FX}$	
		$-BM_{SEK}$	**(3)**	+Foreign goods/ Securities	
				$-BM_{SEK}$	
			Σ	+Foreign goods/ Securities	

Balance Sheets 20 and 21 display a possible explanation for the balance sheet differences visible in Table 7 with positive net foreign currency liabilities and negative net domestic currency deposits. If the domestic non-bank sector wishes to obtain foreign currency it may approach the domestic banking system, which in turn borrows foreign currency from another source, entry (**1**). In entry (**2**) the banking system performs a foreign exchange transaction with the domestic non-bank sector by selling its foreign currency against domestic deposits, as a result domestic bank money is destroyed. This is the case exhibited in Table 3, case 3.6 with opposite signs. The non-bank sector may then use its foreign currency in order to import foreign goods or buy foreign

securities, entry (**3**). Thus there exists a perfectly reasonable explanation for the composition of the Swedish banking system's balance sheet, using the endogenous money approach, with the effect of foreign currency denominated debt replacing domestic deposits in SEK.

7.3. Analysis of Variation

Appendix B3 shows the correlations between assets and liabilities from Table 7, it shows that all asset and liability categories positively correlate, but that within a category the corresponding assets and liabilities have very high correlations. Table 8 shows the correlation between the differences of asset categories.

Table 8: Correlation Matrix for 'Differences within Asset Categories'

Correlation Matrix	FX Assets - FX Liabilities	Securities in SEK - Debt in SEK	Loans in SEK - Deposits in SEK	-1×Equity
FX Assets - FX Liabilities	1,0000	0,1772	-0,7333	0,6915
Securities in SEK - Debt in SEK	0,1722	1,0000	-0,7669	0,2107
Loans in SEK - Deposits in SEK	-0,7333	-0,7669	1,0000	-0,7096
-1×Equity	0,6915	0,2107	-0,7096	1,0000

Datasource: Statistics Sweden, 2016

The shaded cells show that the difference between loans and deposits in SEK correlates negatively with the other differences, indicating that an increase in deposits without increase in loans can be compensated for by changing differences in the other asset categories.

Figure 1 displays the monthly differences in asset categories over time which at each point of time sum up to zero. It is visible that the equity varies much less than the other series. In December 2015 the difference of foreign currency assets and liabilities and equity finance the difference between loans and deposits in SEK. One can see that it is a long and variable process in which debt denominated in foreign currency replaces domestic deposits in SEK. Additionally debt in SEK also sometimes fills the funding gap for loans, whenever the corresponding line in Figure 1 falls below zero.

Figure 1: Swedish Banking System Asset Category Differences

Datasource: Statistics Sweden, 2016
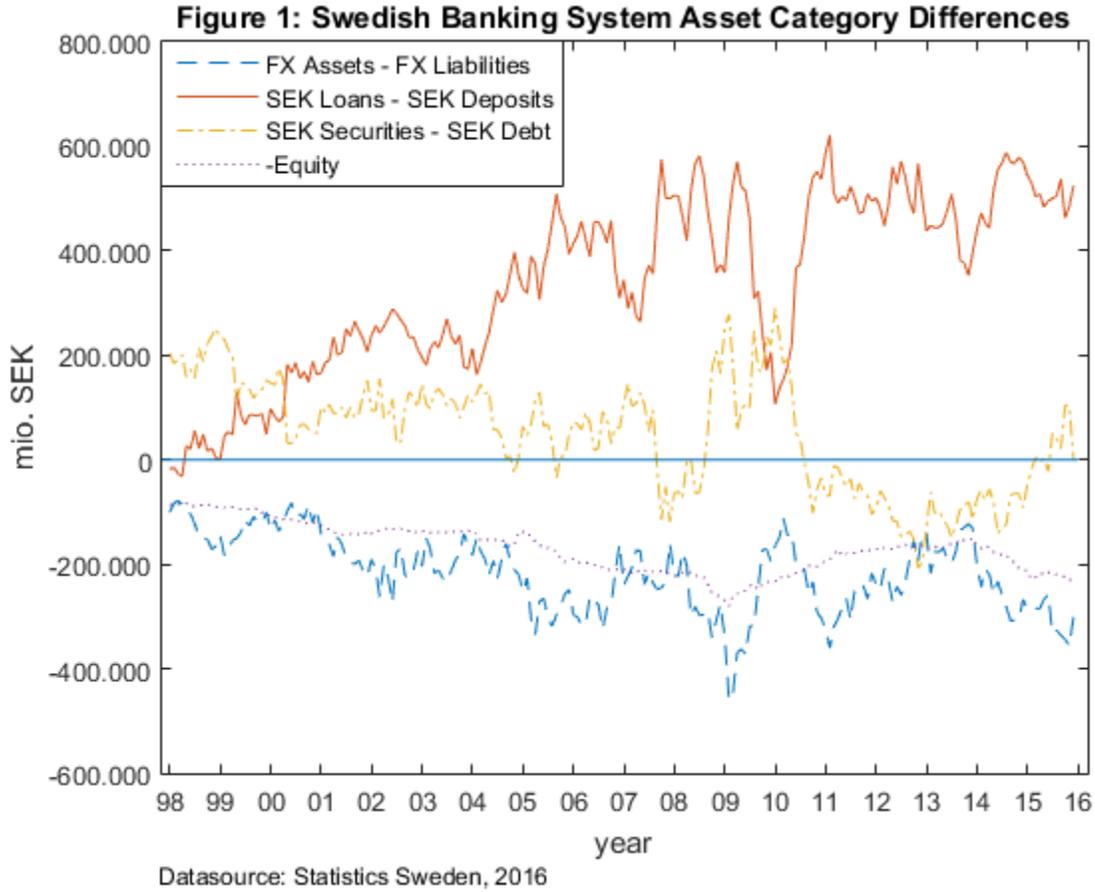
Table 9: Correlation Matrix for Monthly Changes in 'Differences within Asset Categories'

Correlation Matrix	Δ (FX Assets - FX Liabilities)	Δ (Securities in SEK - Debt in SEK)	Δ (Loans in SEK - Deposits in SEK)	Δ (-1× Equity)
Δ (FX Assets - FX Liabilities)	1,0000	-0,3851	-0,4452	0,1748
Δ (Securities in SEK - Debt in SEK)	-0,3851	1,0000	-0,6472	-0,1783
Δ (Loans in SEK - Deposits in SEK)	-0,4452	-0,6472	1,0000	-0,0910
Δ (-1× Equity)	0,1748	-0,1783	-0,0910	1,0000

Datasource: Statistics Sweden, 2016

Table 9 displays a correlation matrix for the monthly changes of the asset category differences over time. The shaded cells show that the negative correlations to the monthly change in differences of domestic currency loans and domestic currency deposits differ by asset category.

The monthly changes in differences of domestic currency loans minus deposits is thus mostly explained by changes in differences in securities denominated in SEK and changes in the differences of foreign currency assets and liabilities. This is also confirmed in Table 10 in which the variation explained can be obtained from R^2. Different variables included show that entries (**7**) and (**8**) have the greatest explanatory power of the variation in changes of the difference in domestic currency loans and deposits. Entries (**4**), (**5**) and (**6**) indicate similar conclusions as Table 9.

Table 10: Regression Results for the Monthly Change in Balance Sheet Differences with Δ (Loans in SEK - Deposits in SEK) as Dependent Variable					
	Intercept	Δ (FX Assets - FX Liabilities)	Δ (Securities in SEK - Debt in SEK)	Δ (-1× Equity)	Variation Explained
	β_0	β_1	β_2	β_3	R^2
(1)	-	-1	-1	-1	1
(2)	-0,002	-1	-1	-1	1
(3)	-	-0,5580	-	-	0,200
(4)	1866,6	-0,5568	-	-	0,198
(5)	1770,3	-	-0,6621	-	0,419
(6)	1798,9	-	-	-0,7253	0,008
(7)	-	-1,0203	-0,9838	-	0,985
(8)	700,4	-1,0196	-0,9833	-	0,985
(9)	1792,6	-0,5538	-	-0,1087	0,198
(10)	545,8	-	-0,7010	-1,6984	0,463

Datasource: Statistics Sweden, 2016

Note that for the beta values it is only of interest if they are close to the true values of '-1'. The value of '-1' must hold if all variables including the dependent variable sum up to zero. As the true values of the betas are known, their estimation is not of main focus. Relevant for the analysis are only the shares of each of the three explanatory variables contributing to the total variance of the dependent variable. Entry (**1**) shows the case in which all variables are included which

naturally explains all the variation. For this reason combinations of excluded variables are pursued in order to grasp the variations. Descriptive statistics of the variables are provided in Appendix B4.

7.4. Implications from the Empirical Analysis

Implications can be derived in that the endogenous money effect exists and is considerable in size. Table 7 shows that around 300 bn. SEK in the Swedish banking system have been replaced by debt denominated in foreign currency. The observed effect is one of endogenous money destruction due to the Swedish banking system borrowing foreign currency in order to exchange it against the domestic non-banking sector against SEK. This effect is much less explained by borrowing foreign currency in order to lend SEK.

The monthly variation of differences in loans in SEK and deposits in SEK can be explained by the differences of securities in SEK and debt in SEK, but also by the differences of foreign currency denominated assets and liabilities. While the securities and debt in SEK can explain a larger part of the variation of the differences in loans in SEK and deposits in SEK, the effect of foreign currency denominated assets and liabilities is large as well and explains a much larger part of the cumulative effect of deposit destruction.

8. Modelling Money Demand and Supply in Foreign Exchange Markets

This chapter emphasizes stock-flow consistent (SFC) modelling as an appropriate tool for analysing endogenous money creation and destruction in foreign exchange markets. The stock-flow consistent approach allows for extensions integrating different aspects of the economy such as different sectors, production, investment flows etc.. Previous research using stock-flow consistent models for endogenous money simulations (e.g. Godley & Lavoie, 2007, ch. 12) only focused on central bank foreign exchange interventions resulting in central bank money being created. This chapter innovates by focusing on banking system involvement in foreign exchange transactions resulting in endogenous bank money creation. Section 8.1 presents the stock-flow consistent model, Section 8.2 describes the assumed sectoral behaviours and Section 8.3 provides the results with Section 8.4 discussing some implications derived from the simulation.

8.1. Stock-Flow Consistent Modelling

Table 11 displays the balance sheets of the involved sectors Non-Banking System A (**NBSA**), Banking System A (**BSA**), Non-Banking System B (**NBSB**), and Banking System B (**BSB**). A and B are two different countries with prevailing currencies A or B. The notation is chosen as $Issuer_{Currency}^{Holder}$ for assets, $Issuer_{Currency}$ for liabilities, special cases are equity $Sector_{Currency}^{E}$ and bank money $BM_{Currency}$ which is issued by the respective banking systems. A positive sign indicates an asset while a negative sign indicates a liability.

Each row denotes a type of asset with corresponding liability, e.g. the first row shows debt issued by NBSA in currency A which has corresponding claims in same size for the other sectors. The liabilities for a certain type of security issued by a sector must have corresponding assets for other sectors, that is, inter-sector financial assets and liabilities, as a result each row must sum up to zero. The summing up to zero is also true for the equity as this model only includes financial assets and liabilities; if one sector has assets larger than liabilities another sector must have liabilities larger than assets, which is realistic only for the case of the non-banking system sectors.

Each column presents the balance sheet of a sector, as the upper four rows show assets in currency A and the lower four rows show assets in currency B an exchange rate xr_A is included such that the cells above the 'Exchange rate' row need to be multiplied by xr_A. Using the exchange rate each asset and liability can be converted to currency B and then the column must

sum up to zero due to the balancing item of equity. A column can thus be interpreted as the sum of assets minus the liabilities including equity of a sector which must result in zero.

Table 11: SFC Model: Balance Sheet					
	NBSA	BSA	BSB	NBSB	Σ
NBSA Debt in A	$-NBSA_A$	$+NBSA_A^{BSA}$	$+NBSA_A^{BSB}$	$+NBSA_A^{NBSB}$	0
Bank Money A	$+BM_A^{NBSA}$	$-BM_A$	$+BM_A^{BSB}$	$+BM_A^{NBSB}$	0
BSB Debt in A	-	$+BSB_A^{BSA}$	$-BSB_A$	-	0
Equity in A	$-NBSA_A^E$	$-BSA_A^E$	$-BSB_A^E$	$-NBSB_A^E$	0
Exchange rate	$\cdot xr_A$	$\cdot xr_A$	$\cdot xr_A$	$\cdot xr_A$	
NBSB Debt in B	$+NBSB_B^{NBSA}$	$+NBSB_B^{BSA}$	$+NBSB_B^{BSB}$	$-NBSB_B$	0
BSA Debt in B	-	$-BSA_B$	$+BSA_B^{BSB}$	-	0
Bank Money B	$+BM_B^{NBSA}$	$+BM_B^{BSA}$	$-BM_B$	$+BM_B^{NBSB}$	0
Equity in B	$-NBSA_B^E$	$-BSA_B^E$	$-BSB_B^E$	$-NBSB_B^E$	0
Σ	0	0	0	0	

Table 11 with its eight relevant rows and four columns is thus a short representation of 12 equations that must hold at all times in order for the model to be stock-flow consistent. It can be simply reduced to explaining that all assets included in the model must have corresponding liabilities.

Table 12 shows the transactions flow matrix which integrates income and expenditure flows as well as investment flows with changes in assets and liabilities. A positive sign denotes an inflow of money and a negative sign denotes an outflow of money. The table is split into the upper half in currency A and the lower half in currency B as is the case with Table 11, such that in order for

the columns to sum up to zero the cells in the upper half need to be multiplied by the exchange rate xr_A.

		NBSA	BSA	BSB	NBSB	Σ
		Table 12: SFC Model: Transactions Flow Matrix				
Flows in A	NBSA Debt in A	$-r_A \cdot NBSA_A$	$+r_A \cdot NBSA_A^{BSA}$	$+r_A \cdot NBSA_A^{BSB}$	$+r_A \cdot NBSA_A^{NBSB}$	0
	Bank Money A	$+r_A^{BM} \cdot BM_A^{NBSA}$	$-r_A^{BM} \cdot BM_A$	$+r_A^{BM} \cdot BM_A^{BSB}$	$+r_A^{BM} \cdot BM_A^{NBSB}$	0
	BSB Debt in A	-	$+r_A \cdot BSB_A^{BSA}$	$-r_A \cdot BSB_A$	-	0
	Profits in A	$+P(BSA)_A$	$-P(BSA)_A$	$-P(BSB)_A$	$+P(BSB)_A$	0
Asset Changes in A	NBSA Debt in A	$+\Delta NBSA_A$	$-\Delta NBSA_A^{BSA}$	$-\Delta NBSA_A^{BSB}$	$-\Delta NBSA_A^{NBSB}$	0
	Bank Money A	$-\Delta BM_A^{NBSA}$	$+\Delta BM_A$	$-\Delta BM_A^{BSB}$	$-\Delta BM_A^{NBSB}$	0
	BSB Debt in A	-	$-\Delta BSB_A^{BSA}$	$+\Delta BSB_A$	-	0
	Exchange rate	$\cdot xr_A$	$\cdot xr_A$	$\cdot xr_A$	$\cdot xr_A$	
Flows in B	NBSB Debt in B	$+r_B \cdot NBSB_B^{NBSA}$	$+r_B \cdot NBSB_B^{BSA}$	$+r_B \cdot NBSB_B^{BSB}$	$-r_B \cdot NBSB_B$	0
	BSA Debt in B	-	$-r_B \cdot BSA_B$	$+r_B \cdot BSA_B$	-	0
	Bank Money B	$+r_B^{BM} \cdot BM_B^{NBSA}$	$+r_B^{BM} \cdot BM_B^{BSA}$	$-r_B^{BM} \cdot BM_B$	$+r_B^{BM} \cdot BM_B^{NBSB}$	0
	Profits in B	$+P(BSA)_B$	$-P(BSA)_B$	$-P(BSB)_B$	$+P(BSB)_B$	0
Asset Changes in B	NBSB Debt in B	$-\Delta NBSB_B^{NBSA}$	$-\Delta NBSB_B^{BSA}$	$-\Delta NBSB_B^{BSB}$	$+\Delta NBSB_B$	0
	BSA Debt in B	-	$+\Delta BSA_B$	$-\Delta BSA_B^{BSB}$	-	0
	Bank Money B	$-\Delta BM_B^{NBSA}$	$-\Delta BM_B^{BSA}$	$+\Delta BM_B$	$-\Delta BM_B^{NBSB}$	0
	Σ	0	0	0	0	0

Further, each half of the table is separated into income and expenditure flows, as well as asset and liability changes. Income and expenditure flows depend on the current size of assets and liabilities and their corresponding interest rates $r_{Currency}$ for assets denoted in the respective currency as well as $r_{Currency}^{BM}$ to allow for differing interest rates on regular assets or bank deposits.

The sign of the cell determines the flow of money, but there is a notational convention to follow. $+\Delta NBSA_A$ for example explains that if NBSA issues new liabilities in currency A, the delta would then be positive, this is a money inflow for NBSA. Alternatively $-\Delta NBSB_B^{NBSA}$ shows that if NBSA bought more securities issued by NBSB, the delta would be positive, this would result in a money outflow. Nevertheless $-\Delta BM_A^{NBSA}$ suggests that NBSA increasing its bank money holdings results in a money outflow, which could be interpreted as buying a liability issued by the bank. This is necessary as NBSA's increased holdings of bank money must also increase the liabilities that Banking System A owes to NBSA.

Each row of the 'Flows' expresses that an expenditure due to an asset must result in a corresponding income for another sector due to the same asset. Each row in the 'Asset Changes' ensures that if one sector reduces or increases a specific asset or liability this must be met with a corresponding change of this asset or liability in another sector. Profits $P(Banking\ System)_{Currency}$ are paid from the banking systems to their respective national non-banking systems, the rows regarding profit flows are simplified into one row even though they could be split into two separate equations for each currency.

The columns ensure that a sector's income and expenditure flows correspond to changes in assets. For example if NBSA receives an income in B it must either spend it by purchasing new assets or save it by lending it to the bank and holding bank money B.

Transactions between sectors commonly affect at least four cells, if one cell changes a second cell in the same row must change in order to equate the row to zero, but also a third cell in the same column must change in order to ensure that the sum of the elements in the column remains zero. At last a fourth cell must be changed that is in the same column as the second cell and in the same row as the third cell.

From the equations displayed in the rows and columns in Table 12 one can recognize the difference between banking systems and non-banking systems. In non-banking systems

transactions occur such that bank money and regular assets replace each other, the balance sheet size remains the same. For example NBSA buying or selling securities issued from NBSB, $-\Delta NBSB_B^{NBSA}$ and $-\Delta BM_B^{NBSA}$ have the same sign in the column equation that must result in zero. Thus if no other assets are affected, when NBSA increases or reduces its holdings in $NBSB_B^{NBSA}$, its holdings in BM_B^{NBSA} must be reduced or increased correspondingly. For banking systems using their own liability for payments the opposite is the case. For example $-\Delta NBSB_B^{BSB}$ and $+\Delta BM_B$ have opposite signs such that due to the column being equal to zero a purchase of $NBSB_B^{BSB}$ results in an increase in bank money BM_B. The endogenous money creation and destruction process is therefore well reflected in the transactions flow matrix.

The equations defined by the transactions flow matrix and also the balance sheet must hold for each individual transaction and thus also for accumulated transactions over a given time period. The compliance of all included assets, liabilities and flows with these equations is what ensures the model to be stock-flow consistent. This compliance also ensures the appropriate endogenous money creation and destruction due to common bank transactions but also foreign exchange transactions between the different sectors.

8.2. Sector Behaviour

The balance sheet and the transactions flow matrix ensure stock-flow consistency, but the behaviour of the different sectors needs to be defined. A more detailed account expressing the relevant equations is presented in Appendix C1. The following presents the summary of an exemplary SFC model. This includes the choice of assets and liabilities already presented in the previous section.

The starting values are chosen to be 100 for the assets $NBSA_A^{BSA}$, $NBSB_B^{BSB}$, BM_A^{NBSA}, BM_B^{NBSB} with 100 also being the starting value for the corresponding liabilities. All other variables have a starting value of zero. Each sector balance sheet thus has the size of 100 with the non-banking systems holding local bank money and the banking systems holding local assets issued by the non-banking systems. These values are chosen in order to make the result more intuitively interpretable.

Interest rates are chosen to be $r_A = 2\%$, $r_B = 4\%$, and $r_A^{BM} = r_B^{BM} = 0\%$ and remain constant through time. This is in order to create an imbalance in foreign exchange demand and incomes from foreign assets.

For reasons of simplicity profits are chosen not to be paid out from banking systems to non-banking systems. Additionally all types of incomes are assumed to be at first reinvested, this is to overcome the currency mismatch of non-banking systems with foreign assets and domestic liabilities, otherwise the non-banking system would always attempt to sell foreign currency and buy domestic currency in order to pay interest in the correct currency.

After the income flows are reinvested the non-banking systems perform a rebalancing of their assets in order to reach a target level of 30% foreign assets for NBSA and 10% foreign assets for NBSB. Different values are chosen such that the banking system can provide the difference endogenously.

In the model the mismatch between foreign exchange demand and supply between NBSA and NBSB must be met through a banking system. There are two options, if e.g. the demand for currency B (supply of A) exceeds the demand for currency A (supply of B), either BSB buys the excess supply of A with newly created bank money B, or BSA borrows newly created bank money B from BSB in order to clear the market. This model chooses the first option in order to display the effect of endogenous money creation instead of destruction.

The next question is what BSB would do with its newly acquired currency A. It is assumed that it uses currency A to purchase newly issued securities by NBSA, which endogenously fulfills the demand for its liabilities. This occurs as there is only one investment asset available for BSB, namely NBSA securities. Other 'active' bank portfolio decisions are excluded.

At last the exchange rate mechanism must be defined. It could be defined through interest rate differentials or other economic factors, but is chosen to follow bank money changes over time as a proxy for exchange rate risk arising through the currency mismatch of the banking system acquiring foreign currency. The multiplier that determines the change in the exchange rate is visible in the Equation (**1**). It ensures that a banking system increasing its foreign currency exposure is compensated through exchange rate movements, or as an explanation, the banking system as a market maker would change its bid and ask prices correspondingly.

$$xr_A(t) = xr_A(t-1) \times \frac{BM_A(t)/BM_A(t-1)}{BM_B(t)/BM_B(t-1)} \tag{1}$$

8.3. Results

The results of the simulation done in MATLAB for the stock-flow consistent model depend immensely on the chosen variables, starting values, and assumed behaviours of the sectors, interest rates and exchange rates. For a more in-depth analysis it would be important to assimilate real world values and behaviour and observe if the simulations can explain economic reality.

Figures 2 to 5 show the balance sheets of the four involved sectors with their most important assets and liabilities, assets are displayed positive and liabilities negative. The same type of asset and liability pairs are displayed in similar formatting in all four figures. Each asset or liability is presented in the currency it was issued in, i.e. the y-axis presents either currency A or currency B depending on the asset observed.

In Figure 2 we can see that NBSA increases its holdings in NBSB assets, but it also issued new liabilities to finance its purchase. This is due to BSB stepping in the foreign exchange market to buy the excess currency A and provide bank money B, BSB then uses its obtained bank money A to buy newly issued securities from NBSA. But NBSB obtained NBSA assets as well, so that BSB only filled the imbalance between the demands for foreign assets.

Figure 2: Non-Banking System A Assets & Liabilities

Figure 3: Non-Banking System B Assets & Liabilities
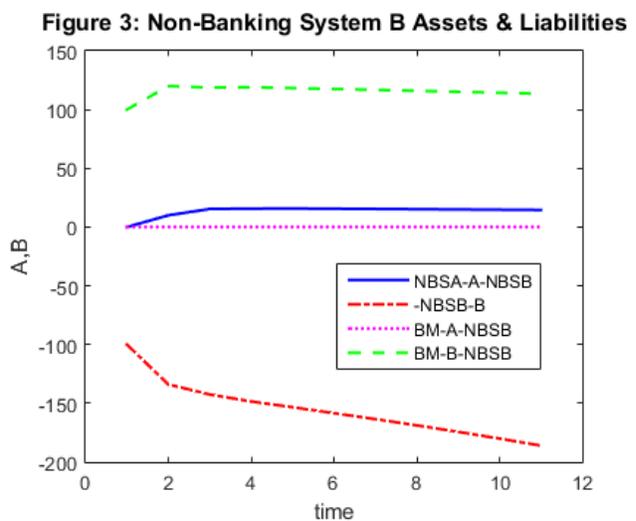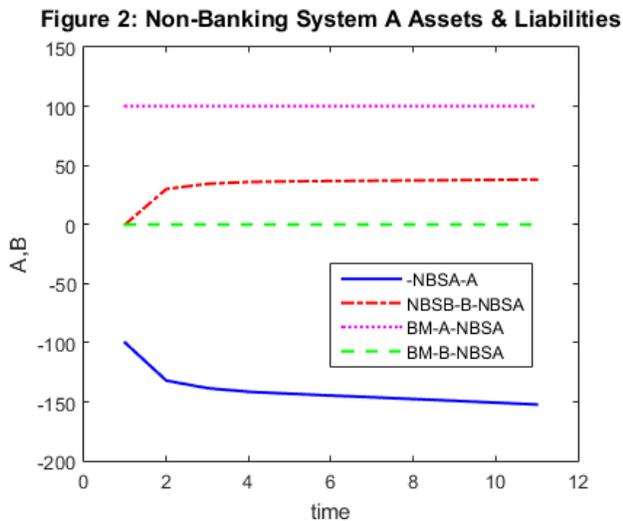
Bank money B increases and the sector holding this newly created bank money in the end is NBSB. Bank money A remains constant. The graphs display a slow increase in the assets and liabilities of the non-banking systems due to reinvestment of the interest receipts. The difference in interest rates and the exchange rate movements explain the slow reduction in bank money B after the prior increase.

Figure 4: Banking System A Assets & Liabilities

Figure 5: Banking System B Assets & Liabilities
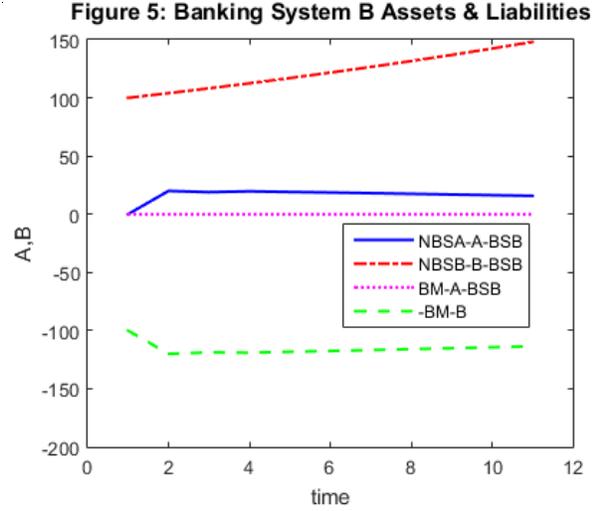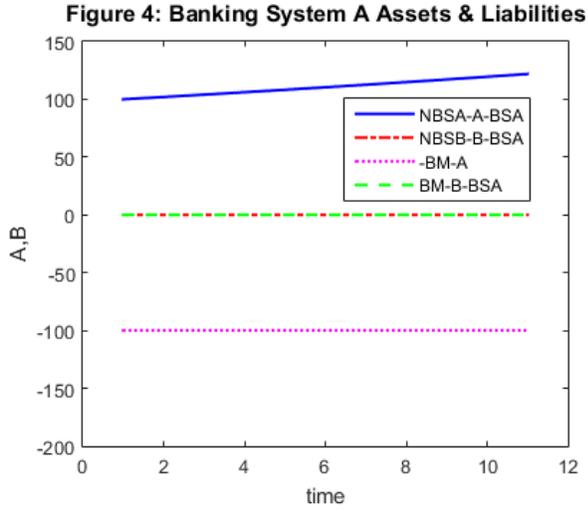
Table 13 displays the foreign exchange demand imbalances and that BSB accommodates the difference. In order for the demands to be comparable the columns for NBSA and NBSB both have the currency unit of A. The last column shows the changes in exchange rate arising from foreign exchange imbalances. The exchange rate is assumed to change directly after the respective banking system removes the imbalances.

t	NBSA demand for B (in A)	NBSB demand for A (in A)	Imbalance	BSA inactive in FX	BSB creates/ destroys difference	FX-rate changes
			Table 13: Foreign Exchange Market Imbalances			
1	30	10	20	-	+20	-16%
2	3,792	5,220	-1,428	-	-1,428	+1%
3	0,281	-0,040	0,321	-	+0,321	-0,23%
4	-1,183	-0,222	-0,961	-	-0,961	+0,68%
5	-1,355	-0,498	-0,857	-	-0,857	+0,62%
6	-1,429	-0,502	-0,928	-	-0,928	+0,68%
7	-1,433	-0,512	-0,921	-	-0,921	+0,68%
8	-1,433	-0,509	-0,925	-	-0,925	+0,69%
9	-1,430	-0,505	-0,924	-	-0,924	+0,70%
10	-1,426	-0,501	-0,924	-	-0,924	+0,71%

The negative results starting from $t = 4$ are due to the assumption of interest on bank money being zero. After the initial portfolio rebalancing in $t = 1$ and $t = 2$ the incomes for both non-banking systems arise from foreign assets which at first are assumed to be reinvested, but then

during the rebalancing process both wish to reduce their foreign exposure in order to bring it down to the target level.

8.4. Implications from the Stock-Flow Consistent Simulation

The main finding of the simulation is to be aware not only of the money creation process, but also of corresponding non-monetary financial assets. In this simulation NBSA wanted to use its domestic money to buy foreign assets and succeeded, but the bank money A that was sold was again reinvested in its own sector.

This raises issues on how the initial bank money A was obtained within the NBSA sector in order to purchase foreign assets, e.g. by selling some securities, as it could possibly be an asset switch between two economies. Nevertheless the endogenous creation of money in country B could affect the number of financial assets in country B as well, or more closer to reality, the asset prices in country B, if no further financial assets are issued.

In comparison to previous findings this chapter concludes that how the endogenously created money is used is very relevant especially towards prior existing or endogenously created financial assets. Different possible transactions can be analysed with the stock-flow consistent approach in order to figure any endogenous money or endogenous securities.

At last it is found that the foreign exchange rate may be affected by endogenous money mechanisms which crucially depend on demand and supply functions of the involved sectors and how specifically banking systems provide the service of liquidity in foreign exchange markets.

9. Conclusion

The historic analysis concludes that there exists a long history of banks being involved in foreign exchange operations resulting in endogenous money creation. Modern banks arose from foreign exchange dealers in the Middle Ages. The newly created money from the banking system buying foreign currency determines the financing cost of the deposit rate. Foreign exchange settlement procedures matter, especially in regard to the types of monies involved.

While previous research focuses on balance of payments issues, the duplication of dollars in the Eurodollar market and dealer banks acting in foreign exchange markets, the analysis in this paper provides a detailed account of money creation and destruction involving the different types of sectors. Bank money and central bank money are created and destroyed on a daily basis through bank and central bank involvements in the foreign exchange market. For a full picture of endogenous money also the spending of foreign currency is relevant as it can offset some of the money creation.

The presented mechanisms of money creation and destruction allow an understanding of empirical relationships involving the Swedish banking system. The main empirical finding is that the Swedish banking system borrows foreign currency in order to exchange it with the domestic sector against domestic currency resulting in a destruction of bank money. The empirical results are limited in their scope due to lack of data analysis of non-bank sectoral data such as firms, households and governments. Nevertheless, the importance of how foreign currency was obtained by a sector and from whom is emphasized as an important insight.

The stock-flow consistent model emphasizes that endogenous money creation and destruction should also be examined in relation to changes of financial assets and liabilities as the fundamental question arises how the newly created money is used. Is it used to buy already existing financial assets, newly issued financial assets, or perhaps for the purchase of goods and services. The creation of new money thus allows for feedback effects potentially affecting demand and supply at the foreign exchange market e.g. due to portfolio decisions.

Stock-flow consistent modelling should be expanded to improve the understanding of the dynamics of interacting economies on matters of production and monetary issues in parallel. Godley and Lavoie have provided an excellent starting point for this and their open economy model should be expanded along more financial issues.

The results of this paper are highly relevant for practitioners analyzing the causalities in global liquidity provision potentially affecting financial markets and economies. Further research would thus be recommended in empirically analysing the interaction between banking systems and non-banking systems across different countries and their factors of influence. The factors could include interest rates, exchange rates and the balance of payments. This paper provides a basis to correctly take into account the endogenous money creation in such investigations.

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Appendix

Appendix A (Chpt. 6)

Appendix B (Chpt. 7)

Appendix C (Chpt. 8)

Appendix A

Appendix A0: Notation for Appendices A1-A5

CB_X Central Bank from country X.

BS_X Banking System from country X.

NBS_X Non-Bank Sector from country X.

CBM_X Central Bank Money in currency X.

BM_X Bank Money in currency X.

Sec_X Already existing security issued in country X denominated in currency X.

$\sum$ Asset and Liability pairs created or destroyed. Every asset must have a corresponding liability.

Liab.   Liabilities

<u>Comments</u>

Appendices A1 to A5 present detailed tables of balance sheets of the central bank, banking system, and non-bank sector of several countries explaining further the cases mentioned in Chapter 6. Occasionally the Liability side of the balance sheet is omitted, in those cases it is not affected by the transactions involved.

Appendix A1: Detailed Account of Cases from Table 2 using Balance Sheets

Case	CB_A Assets	CB_A Liab.	BS_A Assets	BS_A Liab.	NBS_A Assets	CB_B Assets	CB_B Liab.	BS_B Assets	BS_B Liab.	NBS_B Assets	Σ
2.1	$+CBM_B$	$+CBM_A$				$+CBM_A$	$+CBM_B$				$+CBM_A$, $+CBM_B$
2.2		$+CBM_A$	$+CBM_A$	$+BM_A$				$+BM_A$			$+CBM_A$, $+BM_A$
	$+CBM_B$							$-CBM_B$			$-$
2.3		$+CBM_A$	$+CBM_A$	$+BM_A$						$+BM_A$	$+CBM_A$, $+BM_A$
	$+CBM_B$							$-CBM_B$	$-BM_B$	$-BM_B$	$-BM_B$
2.4			$-CBM_A$			$+CBM_A$					$-$
			$+BM_B$				$+CBM_B$	$+CBM_B$	$+BM_B$		$+CBM_B$, $+BM_B$
2.5			$+BM_B$	$+BM_A$				$+BM_A$	$+BM_B$		$+BM_A$, $+BM_B$
2.6				$+BM_A$						$+BM_A$	$+BM_A$
			$+BM_B$							$-BM_B$	$-$
2.7			$-CBM_A$	$-BM_A$	$-BM_A$	$+CBM_A$					$-BM_A$
					$+BM_B$		$+CBM_B$	$+CBM_B$	$+BM_B$		$+CBM_B$, $+BM_B$
2.8					$-BM_A$			$+BM_A$			$-$
					$+BM_B$				$+BM_B$		$+BM_B$
2.9					$-BM_A$					$+BM_A$	$-$
					$+BM_B$					$-BM_B$	$-$

Table A1: Detailed Balance Sheets Supplementing Table 2

Appendix A2: Detailed Account of Cases from Table 3 using Balance Sheets

Case	CB_A Assets	CB_A Liab.	BS_A Assets	BS_A Liab.	NBS_A Assets	BS_B Assets	BS_B Liab.	Σ
3.1	–	–	–	–	–	–	–	–
3.2		$+CBM_A$	$+CBM_A$					$+CBM_A$
	$+CBM_B$		$-BM_B$			$-CBM_B$	$-BM_B$	$-BM_B$
3.3		$+CBM_A$	$+CBM_A$	$+BM_A$	$+BM_A$			$+CBM_A,$ $+BM_A$
	$+CBM_B$				$-BM_B$	$-CBM_B$	$-BM_B$	$-BM_B$
3.4		$-CBM_A$	$-CBM_A$					$-CBM_A$
	$-CBM_B$		$+BM_B$			$+CBM_B$	$+BM_B$	$+BM_B$
3.5			$-CBM_A,$ $+CBM_A$					–
			$-BM_B,$ $+BM_B$					–
3.6				$+BM_A$	$+BM_A$			$+BM_A$
			$+BM_B$		$-BM_B$			–
3.7		$-CBM_A$	$-CBM_A$	$-BM_A$	$-BM_A$			$-CBM_A,$ $-BM_A$
	$-CBM_B$				$+BM_B$	$+CBM_B$	$+BM_B$	$+BM_A$
3.8				$-BM_A$	$-BM_A$			$-BM_A$
			$-BM_B$		$+BM_B$			–
3.9					$-BM_A,$ $+BM_A,$			–
					$-BM_B,$ $+BM_B$			–

Table A2: Detailed Balance Sheets Supplementing Table 3

Appendix A3: Detailed Account of Cases from Table 4 using Balance Sheets

Case	CB_A		BS_A		NBS_A	CB_C		BS_C		NBS_C	BS_B		Σ
	Assets	Liab.	Assets	Liab.	Assets	Assets	Liab.	Assets	Liab.	Assets	Assets	Liab.	
4.1		$+CBM_A$				$+CBM_A$							$+CBM_A$
	$+CBM_B$					$-CBM_B$							$-$
4.2		$+CBM_A$	$+CBM_A$	$+BM_A$				$+BM_A$					$+CBM_A$, $+BM_A$
	$+CBM_B$							$-BM_B$			$-CBM_B$	$-BM_B$	$-BM_B$
4.3		$+CBM_A$	$+CBM_A$	$+BM_A$						$+BM_A$			$+CBM_A$, $+BM_A$
	$+CBM_B$									$-BM_B$	$-CBM_B$	$-BM_B$	$-BM_B$
4.4			$-CBM_A$			$+CBM_A$							$-$
			$+BM_B$			$-CBM_B$					$+CBM_B$	$+BM_B$	$+BM_B$
4.5				$+BM_A$				$+BM_A$					$+BM_A$
			$+BM_B$					$-BM_B$					$-$
4.6				$+BM_A$						$+BM_A$			$+BM_A$
			$+BM_B$							$-BM_B$			$-$
4.7			$-CBM_A$	$-BM_A$	$-BM_A$	$+CBM_A$							$-BM_A$
					$+BM_B$	$-CBM_B$					$+CBM_B$	$+BM_B$	$+BM_B$
4.8					$-BM_A$			$+BM_A$					$-$
					$+BM_B$			$-BM_B$					$-$
4.9					$-BM_A$					$+BM_A$			$-$
					$+BM_B$					$-BM_B$			$-$

Table A3: Detailed Balance Sheets Supplementing Table 4

Appendix A4: Detailed Account of Cases from Table 5 using Balance Sheets

Case	CB_A Assets	BS_A Assets	NBS_A Assets	CB_C Assets	BS_C Assets	NBS_C Assets	BS_B Assets	BS_B Liab.	BS_D Assets	BS_D Liab.	Σ
Table A4: Detailed Balance Sheets Supplementing Table 5											
5.1	$+CBM_B$			$-CBM_B$							$-$
	$-CBM_D$			$+CBM_D$							$-$
5.2	$+CBM_B$				$-BM_B$		$-CBM_B$	$-BM_B$			$-BM_B$
	$-CBM_D$				$+BM_D$				$+CBM_D$	$+BM_D$	$+BM_D$
5.3	$+CBM_B$					$-BM_B$	$-CBM_B$	$-BM_B$			$-BM_B$
	$-CBM_D$					$+BM_D$			$+CBM_D$	$+BM_D$	$+BM_D$
5.4		$+BM_B$		$-CBM_B$			$+CBM_B$	$+BM_B$			$+BM_B$
		$-BM_D$		$+CBM_D$					$-CBM_D$	$-BM_D$	$-BM_D$
5.5		$+BM_B$		$-BM_B$							$-$
		$-BM_D$		$+BM_D$							$-$
5.6		$+BM_B$				$-BM_B$					$-$
		$-BM_D$				$+BM_D$					$-$
5.7			$+BM_B$	$-CBM_B$			$+CBM_B$	$+BM_B$			$+BM_B$
			$-BM_D$	$+CBM_D$					$-CBM_D$	$-BM_D$	$-BM_D$
5.8			$+BM_B$	$-BM_B$							$-$
			$-BM_D$	$+BM_D$							$-$
5.9			$+BM_B$			$-BM_B$					$-$
			$-BM_D$			$+BM_D$					$-$

Appendix A5: Detailed Account of Cases from Table 6 using Balance Sheets

Case	CB$_A$ Assets	CB$_A$ Liab.	BS$_A$ Assets	BS$_A$ Liab.	NBS$_A$ Assets	CB$_B$ Assets	CB$_B$ Liab.	BS$_B$ Assets	BS$_B$ Liab.	NBS$_B$ Assets	Σ
6.1	$-CBM_B$						$-CBM_B$				$-CBM_B$
	$+Sec_B$					$-Sec_B$					$-$
6.2	$-CBM_B$							$+CBM_B$			$-$
	$+Sec_B$							$-Sec_B$			$-$
6.3	$-CBM_B$							$+CBM_B$	$+BM_B$	$+BM_B$	$+BM_B$
	$+Sec_B$									$-Sec_B$	$-$
6.4			$-BM_B$				$-CBM_B$	$-CBM_B$	$-BM_B$		$-CBM_B$, $-BM_B$
			$+Sec_B$			$-Sec_B$					$-$
6.5			$-BM_B$						$-BM_B$		$-BM_B$
			$+Sec_B$					$-Sec_B$			$-$
6.6			$-BM_B$							$+BM_B$	$-$
			$+Sec_B$							$-Sec_B$	$-$
6.7					$-BM_B$		$-CBM_B$	$-CBM_B$	$-BM_B$		$-CBM_B$, $-BM_B$
					$+Sec_B$	$-Sec_B$					$-$
6.8					$-BM_B$				$-BM_B$		$-BM_B$
					$+Sec_B$			$-Sec_B$			$-$
6.9					$-BM_B$					$+BM_B$	$-$
					$+Sec_B$					$-Sec_B$	$-$

Table A5: Detailed Balance Sheets Supplementing Table 6

Appendix B (Chpt. 7)

Appendix B1: Detailed Data Selection

The following information on data selection corresponds to the classifications from Statistics Sweden.

Database:	'Monetary Financial Institutions (MFI), assets and liabilities, balance sheets, SEK million by institutions, item, currency and month'.
Institutions:	1.1 Banks
Items:	120 Total Assets
	101 Cash and credit balances at central banks
	102 Treasury bills etc eligible for central bank refinancing
	103 Lending, Total
	105 Bonds and other interest bearing securities
	106 Shares/participations
	109 Intangible assets
	110 Tangible assets
	111 Subscribed capital unpaid
	113A Other assets etc.
	220 Total liabilities and equity
	201 Deposits, Total
	203 Debt securities issued
	204A Other liabilities etc.
	207 Subordinated liabilities
	208 Untaxed reserves
Currency:	Total currency, Foreign currency, SEK.
Month:	1998M01 - 2015M12

It was checked that the liabilities and assets sum up to the total values in order to realize if any items were missing or disparities occur.

The balance sheet of the Swedish banking system presented in Table 7, Section 7.2 uses the following aggregates each split into using SEK or Foreign currency:

Securities:	101 Cash and credit balances at central banks
	102 Treasury bills etc eligible for central bank refinancing
	105 Bonds and other interest bearing securities
	106 Shares/participations
	109 Intangible assets
	110 Tangible assets
	111 Subscribed capital unpaid
	113A Other assets etc.
Debt:	203 Debt securities issued
	204A Other liabilities etc.
Loans:	103 Lending, Total
Deposits:	201 Deposits, Total
Equity:	207 Subordinated liabilities
	208 Untaxed reserves

The analysis in Section 7.3 further aggregates the following positions in foreign currency:

FX Assets: Loans + Securities

FX Liabilities: Deposits + Debt

In the analysis in Section 7.3 the data points December 2010 and February 2014 are omitted due to inconsistency in assets and liabilities not netting out to zero.

Appendix B2: Swedish Banking System Borrowing Foreign Currency for Exchange or for Lending Domestically in Domestic Currency?

The possibility of the Swedish banking system borrowing foreign currency in order to lend in domestic currency sounds extraordinary on the macroeconomic level, but may be reasonable if foreign interest rates are lower than domestic ones. Balance Sheet B1 provides the steps that occur in such a case and it is the same as Balance Sheet 20 but extended by the lending process in the end, entry (**3**).

Balance Sheet B1: Banking System Borrows Foreign Currency for Lending Domestically

(**1**)	$+BM_{FX}$	$+Debt_{FX}$
(**2**)	$-BM_{FX}$	$-BM_{SEK}$
(**3**)	$+Loan_{SEK}$	$+BM_{SEK}$
Σ	$+Loan_{SEK}$	$+Debt_{FX}$

Balance Sheet B2: Non-Bank Sector buys Foreign Currency from Domestic Banking Sector and takes a Loan

(**3**)	$+BM_{SEK}$	$+Debt_{SEK}$
(**2**)	$-BM_{SEK}$	
(**2**)	$+BM_{FX}$	
(**4**)	$-BM_{FX}$	
(**4**)	+ Foreign goods / Securities	
Σ	+ Foreign goods / Securities	$+Debt_{SEK}$

Entry (**1**) in Balance Sheet B1 shows the process of the Swedish banking system borrowing foreign currency from abroad, the other steps for the banking system also involve the non-bank sector. Balance Sheet B2 displays the non-bank sector that in this case borrows SEK, entry (**3**), exchanges it against foreign currency, entry (**2**) and purchases foreign goods or securities, entry (**4**). In this case the Swedish banking system would at first destroy bank money by performing a foreign exchange operation and then create it again due to domestic lending. This is only reasonable if one takes into account the individual banks as actors.

Section 7.2, Table 9, displays the following correlation:

$$Corr\big(\Delta \text{ (Loans in SEK} - \text{ Deposits in SEK)}, \Delta \text{ (FX Assets} - \text{ FX Liabilities)}\big) = -0{,}4452$$

As we know that foreign currency denominated liabilities rise over time in the Swedish banking system the question arises if this occurs together with an increase in Loans in SEK, as displayed

in Balance Sheet B1, or if it occurs together with a reduction in Deposits in SEK, as displayed in Balance Sheet 20. This would answer the issue of the dominating motive and transactions of the Swedish banking system. The following two correlations attempt to answer this question.

$$Corr(\Delta (\text{FX Assets} - \text{FX Liabilities}), \Delta \text{Loans in SEK}) = -0,1412$$

$$Corr(\Delta (\text{FX Assets} - \text{FX Liabilities}), \Delta \text{Deposits in SEK}) = +0,3022$$

Both correlations show the correct sign in order to explain the observed effect, but the correlation of monthly changes of foreign assets minus liabilities to monthly changes in Loans in SEK is much closer to zero than the correlation to monthly changes in Deposits in SEK. From this it is concluded that Balance Sheet 20 provides a better explanation of the observed Swedish banking system balance sheet behaviour than Balance Sheet B1. Perhaps the total effect can be described as a mixture of both alternatives.

Appendix B3: Correlations between Assets and Liabilities from the Swedish Banking System Balance Sheet

Table B1: Correlations between Assets and Liabilities of the Swedish Banking System

Correlations Assets vs. Liabilities	Total Assets	Loans in FX	Loans in SEK	Securities in FX	Securities in SEK
Total Liabilities	1,0000	0,9943	0,9924	0,9508	0,9679
Deposits in FX	0,9457	0,9360	0,9261	0,9367	0,8977
Deposits in SEK	0,9915	0,9883	0,9914	0,9195	0,9718
Debt in FX	0,9875	0,9808	0,9746	0,9597	0,9402
Debt in SEK	0,9859	0,9811	0,9861	0,9095	0,9748
Equity	0,7327	0,7463	0,7600	0,5741	0,7768

Datasource: Statistics Sweden, 2016

Appendix B4: Descriptive Statistics for Changes in 'Differences within Asset Categories'

Table B2: Descriptive Statistics for Changes in 'Differences within Asset Categories'

	Δ (FX Assets - FX Liabilities)	Δ (Securities in SEK - Debt in SEK)	Δ (Loans in SEK - Deposits in SEK)	Δ (-1× Equity)
Mean (mio. SEK)	-793,38	-812,55	2.308,3	-701,41
Variance (mio. SEK)²	1.169.329.196	1.747.321.860	1.828.860.001	28.820.662

Datasource: Statistics Sweden, 2016

Appendix C (Chpt. 8)

Appendix C1: Behavioural Equations for the Stock-Flow Consistent Model

Starting Values ($t = 1$)

Non-Banking System A issued Securities:

$$NBSA_A^{BSA}(1) = 100$$

$$NBSA_A^{BSB}(1) = 0$$

$$NBSA_A^{NBSB}(1) = 0$$

$$NBSA_A(1) = 100$$

Non-Banking System B issued Securities:

$$NBSB_B^{NBSA}(1) = 0$$

$$NBSB_B^{BSA}(1) = 0$$

$$NBSB_B^{BSB}(1) = 100$$

$$NBSB_B(1) = 100$$

Banking System A issued securities in currency B (Banking System A borrows currency B):

$$BSA_B^{BSB}(1) = 0$$

$$BSA_B(1) = 0$$

Bank Money A:

$$BM_A^{NBSA}(1) = 100$$

$$BM_A^{BSB}(1) = 0$$

$$BM_A^{NBSB}(1) = 0$$

$$BM_A(1) = 100$$

Banking System B issued securities in currency A (Banking System B borrows currency A):

$$BSB_A^{BSA}(1) = 0$$

$$BSB_A(1) = 0$$

Bank Money B:

$$BM_B^{NBSA}(1) = 0$$

$$BM_B^{BSA}(1) = 0$$

$$BM_B^{NBSB}(1) = 100$$

$$BM_B(1) = 100$$

Interest Rates

$$r_A = 0{,}02$$

$$r_A^{BM} = 0$$

$$r_B = 0{,}04$$

$$r_B^{BM} = 0$$

Exchange Rate Determination (xr_A = How much B is worth one A)

for $t = 1$: $\qquad\qquad\qquad\qquad xr_A(1) = 1$

for $t > 1$: $\qquad\qquad xr_A(t) = xr_A(t-1) \times \frac{BM_A(t)/BM_A(t-1)}{BM_B(t)/BM_B(t-1)}$

Non-Banking System A Asset Demands

Proportion of portfolio to be held in foreign assets: $\lambda_1 = 0{,}3$

NBSA total assets after incomes and reinvestment (valued in A):

$$TA_A(NBSA) = BM_A^{NBSA}(t) \times (1 + r_A^{BM}) + \frac{1}{xr_A(t)} \times NBSB_B^{NBSA}(t) \times (1 + r_B)$$

NBSA Target value of FX assets as $NBSB_B^{NBSA}$ (valued in currency A):

$$TV_A(NBSB_B^{NBSA}(t+1)) = \lambda_1 \times TA_A(NBSA)$$

NBSA Target value of FX assets minus holdings of NBSB, this is NBSA's demand for currency B (valued in currency A):

$$D_A NBSA_{FX:B} = TV_A(NBSB_B^{NBSA}(t+1)) - \frac{1}{xr_A(t)} \times NBSB_B^{NBSA}(t) \times (1 + r_B)$$

NBSA demand for currency B (valued in B):

$$D_B NBSA_{FX:B} = xr_A(t) \times D_A NBSA_{FX:B}$$

Non-Banking System B Asset Demands

Proportion of portfolio to be held in foreign assets: $\lambda_2 = 0,1$

NBSB total assets after incomes and reinvestment (valued in B):

$$TA_B(NBSB) = BM_B^{NBSB}(t) \times (1 + r_B^{BM}) + xr_A(t) \times NBSA_A^{NBSB}(t) \times (1 + r_A)$$

NBSB Target value of FX assets as $NBSA_A^{NBSB}$ (valued in currency B):

$$TV_B(NBSA_A^{NBSB}(t+1)) = \lambda_2 \times TA_B(NBSB)$$

NBSB Target value of FX assets minus holdings of NBSA, this is NBSB's demand for currency A (valued in currency B):

$$D_B NBSB_{FX:A} = TV_B(NBSA_A^{NBSB}(t+1)) - xr_A(t) \times NBSA_A^{NBSB}(t) \times (1 + r_A)$$

NBSB demand for currency A (valued in A):

$$D_A NBSB_{FX:A} = xr_A(t) \times D_B NBSB_{FX:A}$$

Foreign Exchange Market

Demand for currency A = supply for currency B (in A) = NBSB demand for A (in A):

$$D(A) = D_A NBSB_{FX:A}$$

Supply of currency A = demand for currency B (in A) = NBSA demand for B (in A):

$$S(A) = D_A NBSA_{FX:B}$$

FX Endogenous Money fulfillment by a Banking System

If $D(A) > S(A)$, then BSA provides the difference to clear the market with:

$$FX_{BSA} = D(A) - S(A)$$

If $D(A) < S(A)$, then BSB provides the difference to clear the market with:

$$FX_{BSB} = S(A) - D(A)$$

However, exchange rate swings with changing demands and supplies for both currencies such that sometimes $D(A) > S(A)$ and sometimes $D(A) < S(A)$ would always result in money creation in either country A or B. Thus an additional condition is implemented such that if BSA or BSB have built up foreign assets in the past, these assets are sold before the other banking system creates new money.

Asset Changes (Endogenous fulfillment by Non-Banking Systems)

BSA issued securities in B:

$$BSA_B^{BSB}(t + 1) = BSA_B^{BSB}(t) \times (1 + r_B)$$

$$BSA_B(t + 1) = BSA_B^{BSB}(t + 1)$$

Bank Money A:

$$BM_A^{NBSA}(t + 1) = BM_A^{NBSA}(t) \times (1 + r_A^{BM}) + FX_{BSA}$$

$$BM_A^{BSB}(t + 1) = BM_A^{BSB}(t) \times (1 + r_A^{BM})$$

$$BM_A^{NBSB}(t + 1) = BM_A^{NBSB}(t) \times (1 + r_A^{BM})$$

$$BM_A(t + 1) = BM_A^{NBSA}(t + 1) + BM_A^{BSB}(t + 1) + BM_A^{NBSB}(t + 1)$$

BSB issued securities in A:

$$BSB_A^{BSA}(t + 1) = BSB_A^{BSA}(t) \times (1 + r_A)$$

$$BSB_A(t + 1) = BSB_A^{BSA}(t + 1)$$

Bank Money B:

$$BM_B^{NBSA}(t+1) = BM_B^{NBSA}(t) \times (1 + r_B^{BM})$$

$$BM_B^{BSA}(t+1) = BM_B^{BSA}(t) \times (1 + r_B^{BM})$$

$$BM_B^{NBSB}(t+1) = BM_B^{NBSB}(t) \times (1 + r_B^{BM}) + xr_A(t) \times FX_{BSB}$$

$$BM_B(t+1) = BM_B^{NBSA}(t+1) + BM_B^{BSA}(t+1) + BM_B^{NBSB}(t+1)$$

NBSA issued securities in A:

$$NBSA_A^{BSA}(t+1) = NBSA_A^{BSA}(t) \times (1 + r_A)$$

$$NBSA_A^{BSB}(t+1) = NBSA_A^{BSB}(t) \times (1 + r_A) + FX_{BSB}$$

$$NBSA_A^{NBSB}(t+1) = NBSA_A^{NBSB}(t) \times (1 + r_A) + D_A NBSB_{FX:A}$$

$$NBSA_A(t+1) = NBSA_A^{BSA}(t+1) + NBSA_A^{BSB}(t+1) + NBSA_A^{NBSB}(t+1)$$

NBSB issued securities in B:

$$NBSB_B^{NBSA}(t+1) = NBSB_B^{NBSA}(t) \times (1 + r_B) + D_B NBSA_{FX:B}$$

$$NBSB_B^{BSA}(t+1) = NBSB_B^{BSA}(t) \times (1 + r_B) + xr_A(t) \times FX_{BSA}$$

$$NBSB_B^{BSB}(t+1) = NBSB_B^{BSB}(t) \times (1 + r_B)$$

$$NBSB_B(t+1) = NBSB_B^{NBSA}(t+1) + NBSB_B^{BSA}(t+1) + NBSB_B^{BSB}(t+1)$$