Preliminary
August 5, 2010

How Amsterdam got Fiat Money[1]

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Abstract: We investigate a fiat money system introduced by the Bank of Amsterdam in 1683. Using data from the Amsterdam Municipal Archives, we partially reconstruct changes in the bank's balance sheet from 1666 through 1702. Our calculations show that the Bank of Amsterdam, founded in 1609, was engaged in two archetypal central bank activities—lending and open market operations—both before and after its adoption of a fiat standard. After 1683, the bank was able to conduct more regular and aggressive policy interventions, from a virtually nonexistent capital base. The bank's successful experimentation with a fiat standard foreshadows later developments in the history of central banking.

[1] The authors would like to thank John McCusker for sharing agio data, Lodwijk Petram for sharing the Deutz folios, and Albert Scheffers for help with the balance books. Also, we thank seminar participants at Rutgers University and Charles Sawyer for comments on an earlier draft. We are also indebted to Michelle Sloan for many hours of skilled data encoding. Generous research and travel support was provided by the FRB Atlanta and TCU.

1. Introduction

Financial innovation consists of doing more (trading) with less (collateral). A key innovation, present in all modern economies, is the use of *fiat money*—a kind of virtual collateral whose value derives only from the force of law and custom. Conventional wisdom says that fiat money can enhance liquidity through "credit policy"—the directed relaxation of collateral constraints through a central bank's lending operations, and through "monetary policy"—the beneficial manipulation of economic aggregates through variation of the money stock.[2]

Fiat money, and its implications for policy, are usually seen as the twentieth-century developments. This paper analyzes an earlier and less well known experiment with fiat money, undertaken by the Bank of Amsterdam (*Amsterdamsche Wisselbank*, henceforth AWB or simply "bank"). The Amsterdam experience with fiat money is noteworthy for its originality, its prominence in European financial history, and its compatibility with price stability over a long period (roughly a century: 1680 through 1780). The AWB opened in 1609 as a municipal exchange bank, an institution for facilitating settlement that was common in Early Modern Europe. The focus here is on the period around 1683 when the bank limited its depositors' ability to withdraw coin, and so effectively became a fiat money provider. The fiat money regime remained in place until the bank's dissolution in 1819.

The AWB's transition from exchange bank to central bank has been described by economic historians (e.g., Mees 1838, van Dillen 1934, Neal 2000, Gillard 2004, van Niewkerk 2009), but these contributions do not fully explain the motivation for the transition. If fiat money did indeed lower and smooth the costs of collateral in Amsterdam markets, how were these changes manifested and who benefited? To lapse into modern terminology, what types of monetary and credit policies were undertaken by the world's first central bank?

[2] In its pure form credit policy does not change the stock of money; see e.g., King and Goodfriend (1988).

We try to shed some light on these questions by examining historical data on the AWB. Using ledgers available from the Amsterdam Municipal Archives, we have compiled partial balance sheets, at a daily frequency, for the AWB from 1666 through 1702, a period which includes the fiat money transition. When combined with information from other sources, these data present a revealing picture of the bank's activities.

First, the data clearly show that the fiat money regime facilitated the AWB's lending to a preferred customer, the Dutch East India Company (*Vereenigde Ostindische Compagnie* or VOC, a government-sponsored enterprise employing approximately 50,000 people during our period of interest). The bank lent to the Company both before and after 1683; but afterward this lending becomes more seasonal and regular in nature. Seasonality means that this lending often does not show up in the annual AWB balance sheets assembled by van Dillen (1925) nor in the annual balance sheets of the VOC assembled by de Korte (1984). Lending was cheaper and less risky for the AWB after 1683 because liquid claims on the bank were limited and chances of a run were ameliorated. Lending activities were extensive but, over the period considered, never exposed the bank to substantial credit risk. We find that the 1683 changes also freed the City of Amsterdam to frequently take the bank's retained earnings from this profitable activity.

Secondly, our analysis indicates that both before and after 1683, the AWB regularly engaged in open market operations. Again, however, the character of this intervention evolves under the fiat regime, as the bank became more willing to "drain funds" by selling off its metal stock. Indirect evidence for the increased efficacy of the bank's interventions is provided by the market price of bank of money, which increases following the fiat money transition.

To summarize, the data we analyze show that by the time of 1683 transition, the AWB managers had ample experience with both lending and open market operations. The move to fiat

money simply allowed for more vigorous pursuit of these activities. The markets seem to have applauded the change: following the 1683 reorganization, there was widespread agreement that trading had been enhanced by this new, if puzzling, kind of money. Writing in 1767, James Denham-Steuart offered the following explanation:

> The bank of Amsterdam pays none in either gold or silver coin, or bullion; consequently it cannot be said, that the florin banco [bank money] is attached to the metals. What is it then which determines its value? I answer, That which it can bring; and what it can bring when turned into gold or silver, shows the proportion of the metals to every other commodity whatsoever at that time: such and such only is the nature of an invariable scale.[3]

The rest of the paper is organized as follows. Section 2 sets the historical stage for the 1683 policy change. Section 3 describes and presents the data. Section 4 offers some interpretations of the data. Section 5 discusses related literature, and Section 6 concludes.

2. Historical prologue

For Amsterdam, the original purpose of its exchange bank was to protect commercial creditors from the unreliable commodity money in general circulation. Modest debasement and resultant inflation was ubiquitous in the Early Modern Netherlands, so the AWB was to be an island of debt settlement backed by high-quality coins (Quinn and Roberds 2009b). To support settlement, the bank needed to attract metal deposits, get debtors to internally transfer payments to creditors, and deliver out metal of an assured quality. The Dutch chose to follow the model of Venice's *Banco di Rialto* and make the AWB an exchange bank that provided only payment and settlement services (Dehing and 't Hart 1997, 45-6).[4] With no lending, the bank was to cover operating expenses with fees.

[3] (Steuart 1805, 75-76). For another favorable review of the Dutch monetary system see Adam Smith, *Wealth of Nations*, IV.3.20.

[4] Unlike later central banks, the AWB did not issue circulating banknotes.

Asymmetric rules promoted the bank's mission by promoting metal inflows, promoting debt settlement, but discouraging metal outflows. On the accommodating side, the AWB had no fees on deposits or internal transfers.[5] Also, one could present the AWB with precious metal in any form. If a coin had a price assigned by statute, then the bank honored that price. Metal in other forms was valued by precious metal content. And once created, a balance could settle a debt through transfer to the creditor's account. Creditors gained finality and a trusted general collateral claim. Similar to modern large-value payment systems (e.g., Fedwire), the AWB created finality through gross settlement, meaning that the bank payments could credibly be viewed as final because the bank avoided extending credit and never (explicitly) adopted netting of payments.[6]

Withdrawals, in contrast, were more costly. The bank was obliged to supply high-quality Dutch coins at official prices, but the bank was allowed to charge a withdrawal fee of up to 2 percent for silver coins and 2.5 percent for gold coins, though under normal conditions, fees averaged 1.5 percent or less (Van Dillen 1964a, 348; see also Table 2 below). The fees compensated the bank for minting costs and helped cover operating expenses. Most important to our story, however, is that the fees discouraged withdrawals. Some uncertainty also existed, for the bank had discretion regarding which of those Dutch coins it offered at withdrawal. If a customer desired a different coin, then the bank could charge an additional premium based on its role as a moneychanger. Moneychanger fees of some level were necessary to prevent coin-to-coin arbitrage.[7]

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[5] The bank was permitted to charge transfer fees but chose not to until 1683 (van Dillen 1934, 85).
[6] Some qualifications are necessary. The bank cleared payments once every day (Mees 1838, 124-5) so there was in principle scope for multilateral netting at a daily frequency, i.e., the practical seventeenth-century definition of "real-time" gross settlement was probably once per day. Also, an examination of AWB account positions every half year indicates that despite rules to the contrary, some accounts were in an overdraft position during the summer months of peak market activity, particularly before the 1683 transition (Willemsen 2009).
[7] Arbitrage is discussed in more detail in Section 4.

This paper focuses on the consequences of withdrawal structure, yet we stress that the effects of the early AWB's relatively high withdrawal fees varied by customer. Unlike a modern central bank, anyone could open an account, so customers ranged from foreign merchants to financial intermediaries. Among merchants who routinely operated within the bank's internal payment system, fees were a negligible concern, for they did not expect to withdraw balances. Of far greater moment to them was that the city of Amsterdam *required* all large bills of exchange to be settled at the AWB. The requirement created demand for deposits, for bills of exchange were the primary means of commercial credit. The bank's total balances reached 925,562 guilders after one year (van Dillen 1934, 117), and grew sporadically to 8.3 million guilders by 1683.[8]

In contrast, customers who did expect to withdraw specie learned to skip the primary account-to-coin process offered by the bank. One could avoid bank fees by paying for coins outside the bank with free transfer inside the bank. Fee avoidance also meant that potential deposit customers did not bring metal to the bank. By 1650, the outside market in bank balances had deepened as private bankers, called cashiers, emerged as dealers who specialized in holding AWB balances and various coins (Van Dillen 1964a, 366-7).

The secondary market lived on margins within the bid-ask spread of the AWB's primary coin-account market, and the expected costs of the primary market were particularly high for short-term deposits. For example, someone who deposited metal and withdrew it one month later at a 1 percent fee had, in effect, borrowed funds at a simple annualized rate of 12 percent. The AWB was thus an expensive place to "park" specie. Relative costs fell with time, and long-term participants in the Amsterdam payment system, like cashier-bankers, could recoup these "borrowing" costs through their secondary market operations. As a result, the short-term metal mar-

[8] The guilder, also known as the florin, was the unit of account in the Dutch Republic. At the time of the AWB's founding, the guilder did not correspond to an actual coin in circulation.

ket stayed outside the bank, and little metal routinely flowed in or out of the bank. Instead, deposits waited for periods of cheap metal and withdrawals for expensive metal.

2.1 Lending

Lending was the first major deviation from the bank's original plan. While the Bank of Amsterdam avoided loans to individuals, the bank soon began lending to the government: the city, the province of Holland, and the Republic (Van Dillen 1934, 94-100). The bank also lent to government sponsored entities like the VOC.[9] As an example, Table 1 gives the bank's balance sheet at the end of January 1669. The bank's metal-to-deposit ratio is 74 percent. While not a reckless position, the bank needed to be mindful of the threat of a run.

Table 1. Bank of Amsterdam Balance Sheet

January 31, 1669
In Millions of Bank Guilders

Assets	**Liabilities**
4.5 Metal	6.1 Deposits
2.1 Loan to Amsterdam	
0.2 Loan to Holland	
1.1 Loan to VOC	1.8 Capital
7.9 Total	7.9 Total

Source: Amsterdam Municipal Archives, 5077-1314.

[9] The bank's lending activities were widely rumored, but the bank did not publicly acknowledge its lending activity until much later. See, e.g., Steuart (1805, 403).

Indeed, the French invasion of the Dutch Republic triggered a run in June 1672, during which (our calculations find) the bank lost 34 percent of its balances in two weeks.[10] Both the Province of Holland and the VOC suspended debt payments, but the bank successfully passed this test, helped in part by the deterrent effect of withdrawal fees.[11] More importantly, the fees had kept the large yet volatile short-term specie flows out of the bank. This absence directly reduced the scale of the run and spared the bank the adverse signals produced by the sudden flight of short-term capital.

Evidence also suggests that the bank adjusted fees to affect withdrawal rates, for the bank raised fees in 1672 and kept them high for years afterward. Average fees can be estimated from the ratio of the bank's non-interest revenues as a percentage of total withdrawals from 1666 to 1681; these ratios are reported in Table 2. The calculation is possible because the bank reported its revenue for these years.[12] From total revenue, we subtract interest from loans to get a numerator that is an imperfect proxy for fee revenue because we do not know the extent of non-withdrawal revenue from sources like overdraft fees, bullion trading, etc., so we cannot explain what loss adjustment created an outlier like the 1676 observation. The denominator we have constructed from the AWB's ledgers, and we are missing complete withdrawal information for three of the years. Peering through noise and missing years, fees rose in 1671 as war fears and withdrawals mounted, fees jumped in 1672 with the panic, and fees remained high until at least 1675.

[10] On June 14, 1672, the AWB's total balances were 7.6 million guilders. Balances had fallen to 5.0 million by June 30 with a metal stock at an estimated 4.5 million.
[11] For sovereign debt, see Gelderblom and Jonker (2010). For the VOC, see de Korte (1984, 66).
[12] After 1683, the AWB reported only profit: revenue less expenses.

Table 2. Non-Interest Revenues as a Percent of Withdrawals

1666	1667	1668	1669	1670	1671	1672	1673
0.76%	0.79%	0.84%	0.93%	0.78%	1.24%	2.19%	NA
1674	1675	1676	1677	1678	1679	1680	1681
1.61%	1.53%	0.13%	NA	1.00%	NA	1.00%	1.78%

Source: See Appendix A.

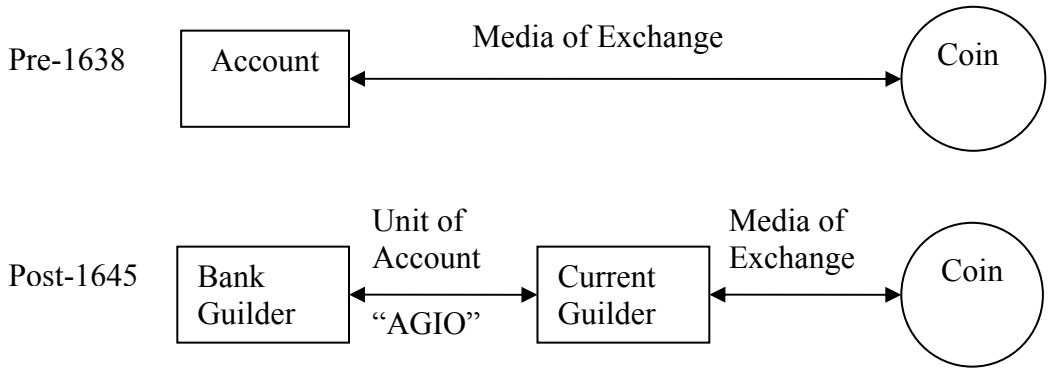
2.2 The Bank Guilder

The other major deviation from the bank's original scheme requires some background, for it defies conventional expectations, then and now (Quinn and Roberds 2009a). In 1638, the Dutch Republic raised the official price of a coin called the Cross Rixdollar or Patagon, a coin minted in the neighboring Spanish Netherlands. The invading Patagon intentionally contained 4 percent less silver than the domestic Rixdollar issued by the AWB. The new price put the bank in an unsustainable position, for the 1638 rule said that the bank had to accept Patagons at 2.5 guilders each, but the old rules made the bank to offer out Rixdollars at the same price. After a period of arbitrage losses, the bank switched to giving out Patagons at withdrawal — a 4 percent "haircut" for depositors. To then make depositors whole in terms of silver, but still avoid rekindling arbitrage, the AWB decided in 1645 to reduce the price of Patagons *at the bank* by 4 percent, from 2.5 to 2.4 guilders each. So, in the end, a customer received 4 percent more coins per guilder, but each coin held 4 percent less silver.

This ad hoc solution had the unintended effect of creating a separate unit of account for bank funds, the *bank guilder*, distinct from the *current* (non-bank) *guilder* (Quinn and Roberds 2007). How so? The Patagon was worth 2.4 bank guilders inside and 2.5 current guilders out-

side.[13] In turn, a secondary market developed between the two units of account. Figure 1 offers before and after schematics. Before 1638, each type of coin had a direct secondary market relationship with the bank that swapped media of exchange: coins for accounts. After 1645, the secondary market focused on exchanging units of account: bank guilders for current guilders. A separate price then traded current guilder accounts at cashier-bankers into coins.

Figure 1. Secondary Market Structure



The exchange market between bank guilders and current guilders deepened to become the principal measure of the value of the bank guilder. The exchange rate was called the agio, and the market measured the agio as the premium commanded by bank guilders. For example, if the agio was 3, then 100 bank guilders bought 103 current guilders. To the extent that the metal content of current money changed only slowly after 1659, the agio can be thought of as a price of bank money in terms of a reference collateral good, i.e. silver. Because of the relatively high withdrawal fees, however, the primary market remained little used.

[13] When the Dutch Republic replaced the Patagon with domestic coins in its 1659 minting ordinance, the state retained the dual price structure and assigned each new coin a distinct bank guilder value, current guilder value, and implicit exchange rate.

2.3 The 1683 restructuring

The changes of the 1680s—the focus of this paper—hinge around the AWB introducing a new primary withdrawal structure that greatly reduced the asymmetry between deposits and withdrawals.[14] In 1683, the bank started to give customers a receipt for the *specific* coins they deposited.[15] At withdrawal, the receipt obliged the AWB to return the same coins at the deposit price. Also, the receipt's redemption fee was only ½ percent for gold and ¼ percent for silver. Customers found the receipt's specific claim and low fee far more attractive than the traditional general claim at a high fee. Customers rushed to use the new facility.

The bank also made receipts negotiable, and resale mattered because the pre-existing stock bank guilders did not get receipts, so about 8 million bank guilders had only the right expensive traditional withdrawal.[16] For new deposits, the 1683 reform unbundled the traditional deposit contract (in which a depositor receives a transferable claim on the bank, plus an option to withdraw) into two separate contracts: the bank guilder account and the receipt. The receipt's option to withdraw metal lasted six months, but one could renew a receipt for another six months by paying the withdrawal fee. Or, instead of paying fees, one could sell the receipt now, and later purchase a receipt if needed. Receipts were especially popular with foreign merchants as a low-cost way of temporarily parking precious metals in Amsterdam, to take advantage of profitable trading opportunities if these presented themselves. Coin could be withdrawn later as necessary, at low cost.

[14] The new structure had been suggested by an Amsterdam businessman, Johannes Phoonsen, in a 1676 essay (van Dillen 1921). At this time the bank also began charging both sides of all transfers 0.00025 percent payable at the end of the fiscal year (van Dillen 1934, 85).
[15] The receipt allowed its holder to claim the coin anytime within a six-month period, i.e., the receipt resembled an American call option on a specific type of coin, or put option on bank funds.
[16] Legally speaking, new deposits were now treated as repurchase agreements between the depositor and AWB (van Dillen 1964b, 395).

Customers learned to trade for the new withdrawal claim instead of exercise the old claim attached to the account, so demand for traditional withdrawal withered. This circumstance allowed the AWB to quietly limit the right to traditional withdrawal sometime in the 1680s.[17] This is when the bank guilder transformed into quasi-fiat money in that one had a right to withdraw metal only if one had a receipt. The stock of bank guilders split into commodity-backed receipts and what Mees (1838) terms an "irredeemable coin of account"—fiat money.

Amsterdam's acquiescence seems to follow from customers not expecting to use traditional withdrawal except, perhaps, during a run on the AWB. We stress that attentive customers could perceive themselves gaining more than they lost. After the introduction of receipts, the option to withdraw the old way was "in the money" only during a run. As mentioned earlier, high fees were one way to mitigate the incentive to withdrawal, but other historical approaches use conditional suspension of payments. In the bank's case, eliminating the collectively dangerous strategy (traditional withdrawal) left a feasible limit on the extent of a run (the stock of receipts), so giving up the option made individuals better off, as long as others also relinquished their option.[18] In the tight-knit world of Dutch political economy, such collective understandings were not uncommon. For example, the provincial governments repeatedly but informally suspended sovereign debt payments during crises with little creditor outcry (Gelderblom and Jonker 2010).

Of course, reducing the threat of runs created new incentives for the AWB that customers might not have foreseen. As we will see later, the AWB expanded its "credit policy" by reducing its capital cushion and more regular lending to the VOC.

[17] Exactly when redeemability was abolished is unknown. To quote van Dillen (1934, 101): "to that great change no ordinance nor any precise date can be assigned." Indirect evidence, described in Section 4, indicates that redeemability had been de facto abolished by 1685.

[18] In this respect, the receipt system amounted to a pledge that later depositors would always have higher priority in the event of a run. The value of similar commitments as a means of limiting bank runs has been shown in theoretical models proposed by Green and Lin (2003), Ennis and Keister (2010), and others.

Finally, moving to receipts and away from traditional withdrawal also meant abandoning the AWB's original symbiosis with Dutch coins. That separation had already begun in 1680 when the Dutch Republic introduced the guilder: a silver coin worth one current guilder. The guilder set a new standard for the Republic's basic circulating coin, but that standard had no official price at the AWB. With no statutory bank-to-current guilder exchange, the AWB was free to set an agio rate for the guilder, to "set a policy rate" in modern terminology.

3. Data

Researchers interested in the activities of modern central banks have access to copious amounts of data. The Federal Reserve System, for example, publishes its balance sheet on a weekly basis (the H.4.1 release) and publishes daily data on the market price of its liabilities (the effective fed funds rate). Some studies have even examined records of individual transactions over central banks' payment systems (for Fedwire, see e.g., Bartolini et al. 2008; Furfine 1999, 2001, 2003, 2006; McAndrews and Potter 2002; McAndrews and Rajan 2000) to analyze money market activity. Almost incredibly, much of this same information is preserved for the Bank of Amsterdam. This section introduces the data used in our investigations.[19]

Turning first to balance sheet data, complete balance sheets for the AWB (breaking down both assets and liabilities) are only available at a yearly frequency.[20] However, the ledgers of the bank, available at the Amsterdam Municipal Archives, record *every* transaction in AWB funds over a given period, so we use the ledgers to reconstruct daily time series of movements in bank liabilities, i.e., changes in aggregate stock of AWB money. Money creation (e.g., deposits) and

[19] The data are described in detail in Appendix A.
[20] These were calculated at the end of every January when the bank was closed to reconcile accounts. See Van Dillen (1925).

destruction (withdrawals) is recorded on ledgers of a bank master account.[21] Similarly detailed records of the bank's metallic assets have not survived. Without the intra-year history of fee revenues, expenses, open market profits or losses, and the like, we cannot construct a complete daily or monthly series for the bank's capital.

Loan assets, however, can be reconstructed at the daily level. Lending to the East India Company in particular is easily detected using a "Furfine algorithm": VOC loans appear as large debit entries to the bank's master account (credits to the VOC), for large sums in round numbers, and (principal) repayments as similar credit entries.[22] Potential open market operations are more problematic. A given debit entry to the bank's master account, for example, may represent an open market purchase, or simply a deposit. Still, we can identify some likely episodes of open market interventions with the help of a second Furfine algorithm, described below.

With the loss of most early ledgers, a reasonably continuous series of extant ledgers only begins in 1666, so our data set starts then. We end in 1702 to capture 35 years of activity surrounding 1683. We focus only on transactions that change the stock of bank guilders. Even so, we have encoded 20,000 individual master account debit transactions (those that created bank guilders through the deposit of metal, purchase of metal, or new lending). Credit transactions (withdrawals, sales, or loan repayments) produced 17,000 individual transactions. To gain visual clarity and compatibility with the agio data, data have been aggregated into monthly observations: levels being the start of a month and flows being month finish less month start. 420 monthly observations are available over the sample period of 444 months. [23]

[21] The *Specie Kamer* or "coin room."
[22] A nearly identical method, pioneered by Furfine (1999), has been used by researchers to filter interbank loan transactions from modern large-value payment system data (e.g. fed funds sales from Fedwire data).
[23] Six half-years are missing out of the 70 half-years covered here. Missing periods are February-July 1673, February-July 1677, September 1672-January 1673, August 1684-January 1685, September 1697-January 1698, and September 1700-Janurary 1701.

Available price data are less complete, but nonetheless extensive. The time series we use is a set of monthly (presumably, average) observations on the market price of bank money (i.e., the agio), spliced together from two sources. The first is an augmented and unpublished version of the agio series in McCusker (1978), generously provided to us by John McCusker. The second is from the records of Joseph Deutz, a prominent Amsterdam merchant, available at the Amsterdam Municipal Archives.[24] The McCusker data cover our whole period, while the Deutz data run from 1662 to 1688. Combining the two data sources yields 290 monthly observations. For some of our econometric exercises (e.g., VARs), the agio series was interpolated to a full sample using a related series, the London price of Amsterdam bills reported in McCusker (1978).[25]

Agios are quoted in sixteenths of a guilder, attesting to the liquidity of the market for bank funds. A sixteenth of a guilder also represented the typical profit margin for a cashier on a bank money trade (Steuart 1805, 405).

3.1. Balances and the Agio

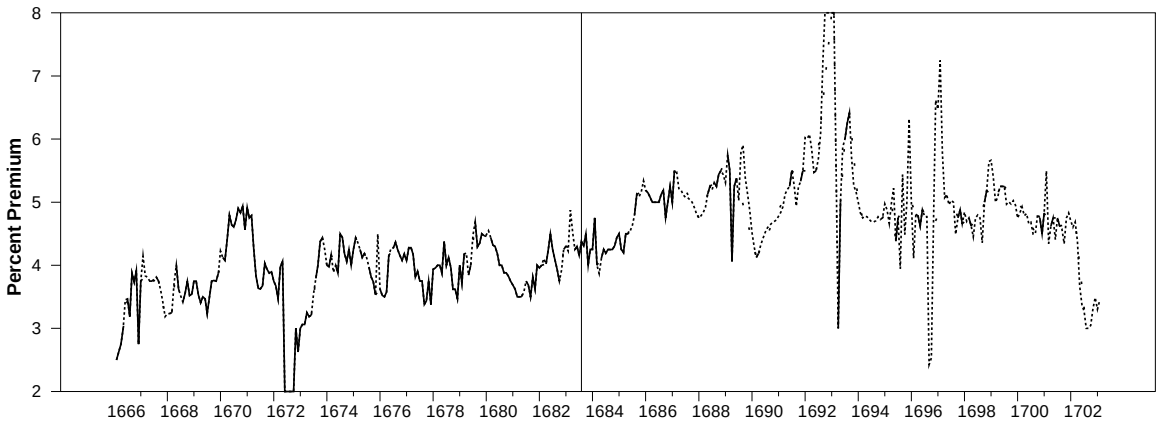
The basic data on quantity (AWB balances) and price (agio) are presented in figures 2 and 3. The gaps in the balance series follow from time's decimation of records. Also, to focus on the routine, figure 3 truncates the very low agio values observed during the 1672 French invasion and very high agio observations in 1693.[26] Interpolated values of the agio are shown as dotted lines in figure 3. Vertical lines in the charts mark the initiation of the receipt system.

[24] Amsterdam Municipal Archives inventory numbers 234 / 290 through 295.
[25] See Appendix A for the details of the interpolation.
[26] The early 1693 spike in the agio resulted from a widely anticipated, legally mandated devaluation of two coins, the shilling and the 28-stiver, that had become severely debased (Mees 1838, 113-114). The coins circulated as current money but were not eligible for deposit at the AWB. The devaluations were for 7 and 8 percent respectively, causing the agio to temporarily run as high as 13 percent (the usual 5 percent premium of bank money above current money plus the amount of the anticipated devaluation).

Figure 2: Monthly AWB balances 1666:2-1703:2

Source: See Appendix A.

Figure 3. Agio, by month, 1666:2-1703:2

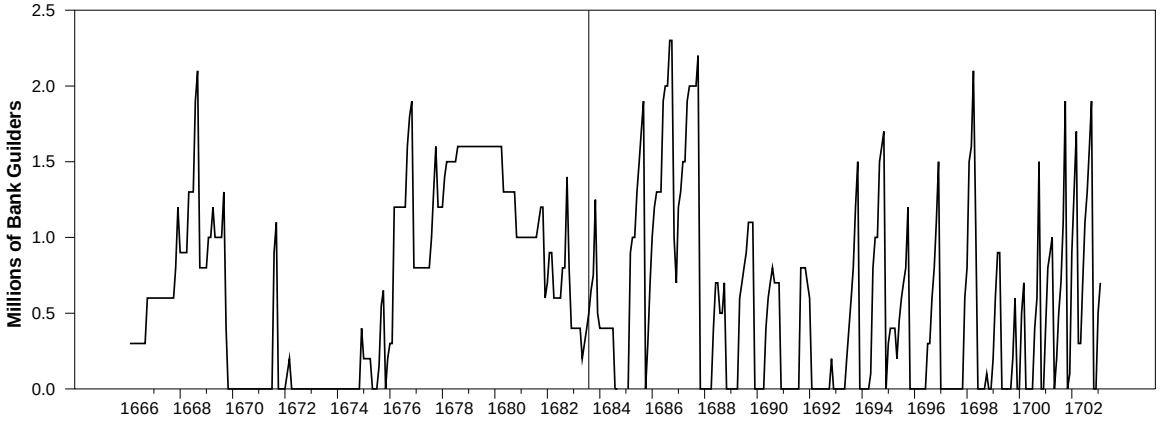


Source: See Appendix A.

3.2 The AWB's uses of funds

The first step in analyzing the asset side of the bank's balance sheet was to strip out VOC loan balances using the procedure mentioned above. These are shown in Figure 4.

Figure 4. VOC loan balances (principal) by month, 1666:2-1703:2



Source: See Appendix A.

Lending to the VOC was an important activity of the bank, both before and after 1683 (Uittenbogaard, 2009). The Amsterdam city council authorized a credit line of 1.7 million in 1682 (Mees 1838, 196), but figure 4 shows that this limit had already been breached in practice. The peak level of VOC indebtedness does not increase after 1683, but the data clearly show that multi-year bank credit to the VOC fell away after 1683 while short-term trough-to-peaks grew.

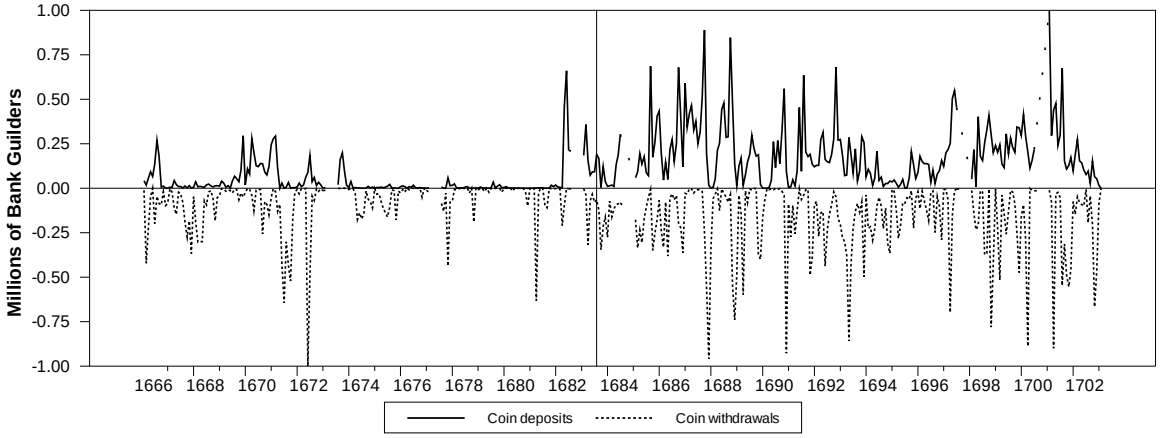
The data challenges are more severe for non-VOC uses of funds. Bank records say nothing about what collateral changed hands when bank guilders were created or destroyed, but the bank did use different accounting channels for different types of transactions. We have identified one channel for coin deposits and another channel for bullion purchases. Essentially, coin deposits are routed through the accounts of the bank's clerical staff, while purchases (i.e., sales of balances) appear directly as debit entries to the bank's master account (see Appendix A for details).

Metal sales by the bank (purchases of balances) do not have a distinct accounting channel, so these sales are (somewhat more tentatively) proxied using another Furfine algorithm: round guilder transactions are assigned as "coin withdrawals" and transactions with fractional amounts to "bullion sales." We describe coins as being deposited and withdrawn because the bank was obliged to accept and return official coins at ordinance prices. Recall that the withdrawal contract

was defined in terms of official coin prices and that altering such prices undermined the collateral structure of all balances. In contrast, the bank had latitude regarding bullion (including non-official coins, metal wire, etc.), and the bank routinely violated what restrictions had been placed on the buying and selling of bullion (van Dillen 1934, 92-3).

Based on this sorting of transactions, much of the increase in balances after 1683 came through more coin deposits. And, as would follow from lower withdrawal fees, there were also more coin withdrawals. Figure 5 presents the amount of coin deposits and withdraws by month from February 1666 to January 1703. Inflow and outflow deepened considerably after the regime change. Note that post-1683 inflows roughly mirror outflows, providing some confirmation for the algorithm used to identify coin withdrawals.

Figure 5. Monthly Coin Deposits and Withdrawals, 1666:2 to 1703:2

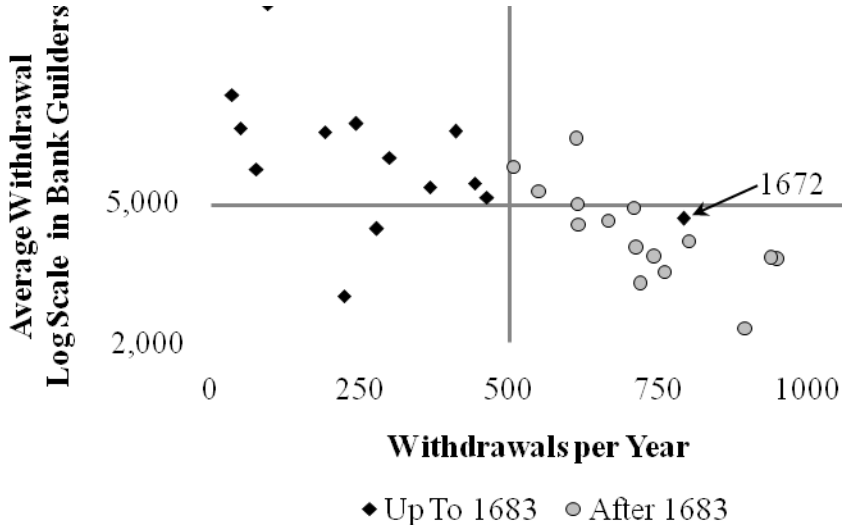


Source: See Appendix A. Note that June 1672 Coin Withdrawals is truncated: the observation's value is -2,478,372 bank guilders.

If the fee reduction facilitated withdrawals (and therefore more deposits), it should also have promoted smaller yet more frequent withdrawals. To check this, figure 6 plots annual withdrawal transactions against the average withdrawal size. By drawing a line at 5,000 guilders, one clearly sees that withdrawal transactions jump after 1683: the outlier being the crisis year of 1672 behaving similarly to a typical year under the receipt system. Withdrawal size shows a

similar pattern with 3 out of 14 early years averaging below 5,000 guilders and 3 out of 15 later years averaging above the same.[27] The series have a correlation of -0.64.

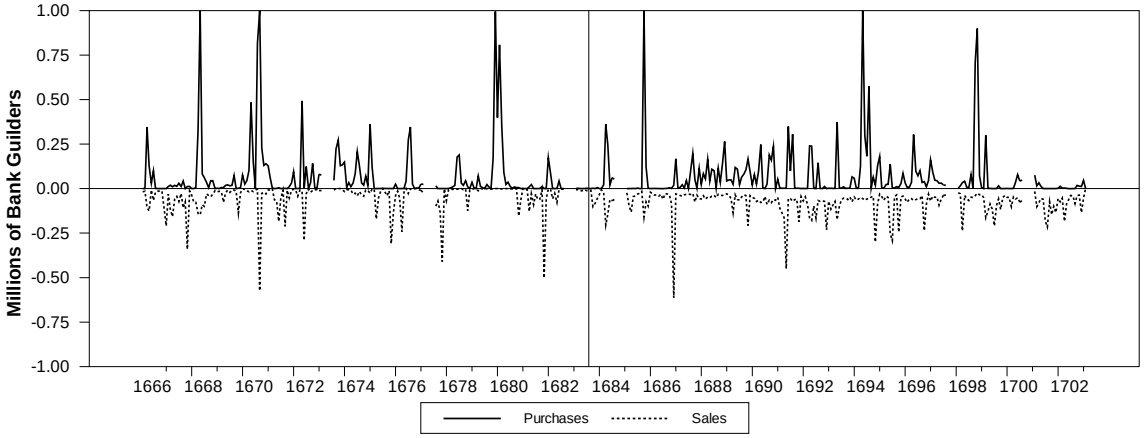
Figure 6: Average Size versus Number of Withdrawals, 1666 to 1702



The transactions we identify as bullion operations show a different pattern. Figure 7 presents our calculation of bullion purchases and sales by month over our sample period. Total purchases before 1683 (14.6 million) roughly equal purchases after (15.4 million), while total sales actually increased from 8.6 million (1666-1682) to 16.7 million (1683-1703). A dramatic aspect of the bullion series is the infrequent spikes that we suspect are large open market operations. There is noticeable asymmetry between sales and purchases: there are 9 months where the AWB purchased more than 700,000 guilders worth of metal, but no months during which the bank sells so much metal.

[27] Note that the vertical scale is logged to enhance visual clarity.

Figure 7. Monthly Bullion Purchases and Sales, 1666:2 to 1703:2

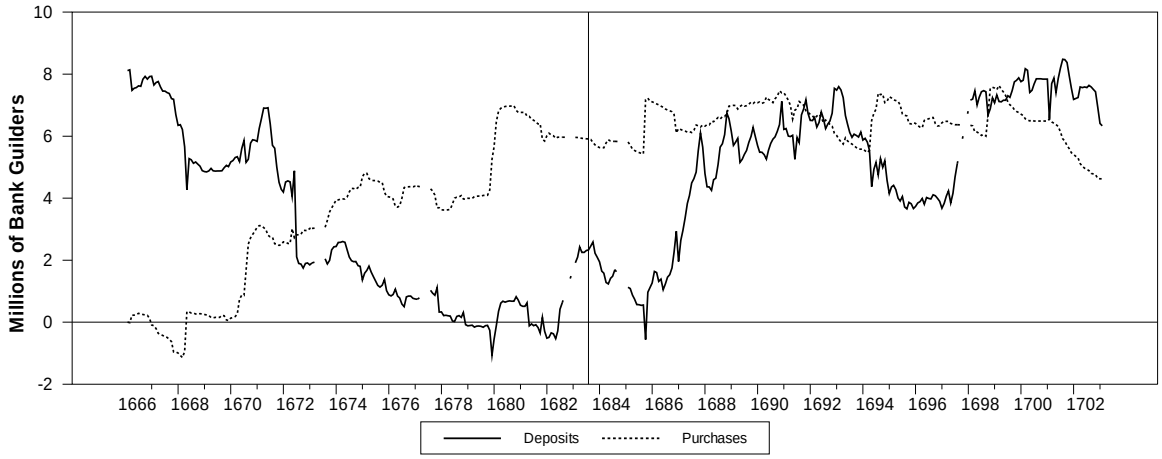


Source: Appendix A.

To finish our partial reconstruction of the asset side of the AWB's balance sheet, the series shown in Figures 5 and 7 must be integrated over time to obtain series on cumulated deposits and cumulated purchases. Since there are no initial values for these two component series, some normalizing assumption is required. We conservatively set the bank's February 1666 purchases to zero, and set the initial value for cumulated deposits to be the entire stock of bank balances, excluding VOC loans. The two series, graphed together in Figure 8, confirm that deposits were a driving force behind the expansion of bank balances post-1683.[28]

[28] Post-1683, cumulated purchases would approximate "outright purchases" of assets on a modern central bank's balance sheet, while cumulated deposits would (again quite roughly) correspond to "repurchase agreements."

Figure 8. Cumulated Net Deposits and Bullion Purchases, 1666:2 to 1703:2



Source: Appendix A.

3.3 Summary statistics

A cursory examination of figures 2-4 suggests that the 1683 regime change had a marked effect on the Amsterdam money markets. Basic statistics on the series confirm this impression. Table 3 reports statistics on the data series before and after the regime change.

Table 3. Statistics on the Agio and AWB Balances

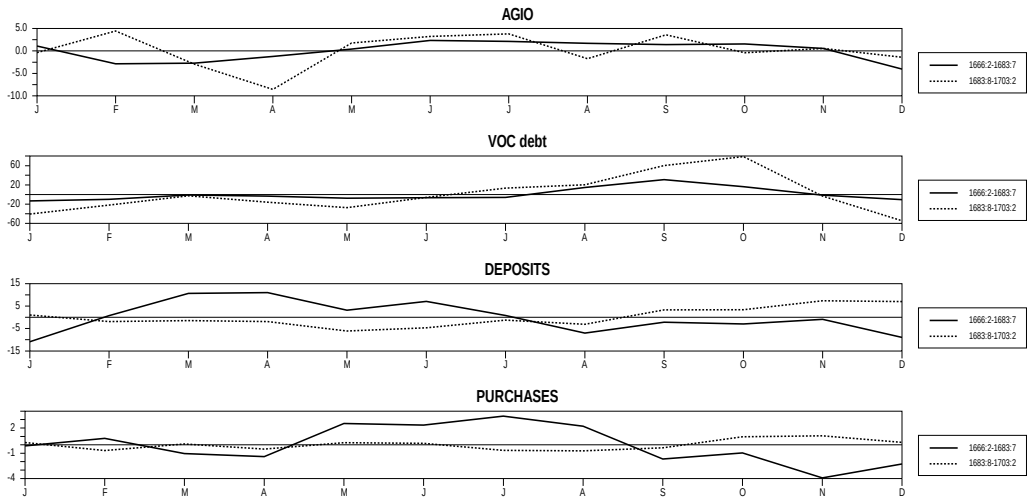
Statistic	Sample	Agio (percent)	Total balances (million guilders)	VOC loan principal	Deposits	Purchases
$\mu(x)$	1666:2-1683:7	3.89	6.79	.685	2.90	3.20
	1683:8-1703:2	*4.83*	*12.51*	*.592*	*5.27*	*6.43*
$\sigma(x)$	1666:2-1683:7	0.458	1.29	.557	2.72	2.31
	1683:8-1703:2	*0.530*	*2.41*	*.623*	*2.15*	*0.656*
$\sigma(\Delta x)$	1666:2-1683:7	0.256	0.413	.231	0.335	0.196
	1683:8-1703:2	*0.407*	*0.586*	*.474*	*0.363*	*0.188*

Source: see Appendix A. Statistics for the agio omit two episodes of outliers: June-October 1672 and January-February 1693.

The table indicates that after 1683 the agio became centered around its statutory level of about 5 percent; it also becomes more variable in both levels and differences. Balances increased due to accumulated metal purchases and an influx of deposits. Outstanding loans to the VOC averaged about the same before and after 1683, but these become less smooth after the reform. Purchases are notably less variable after the 1683 reform.

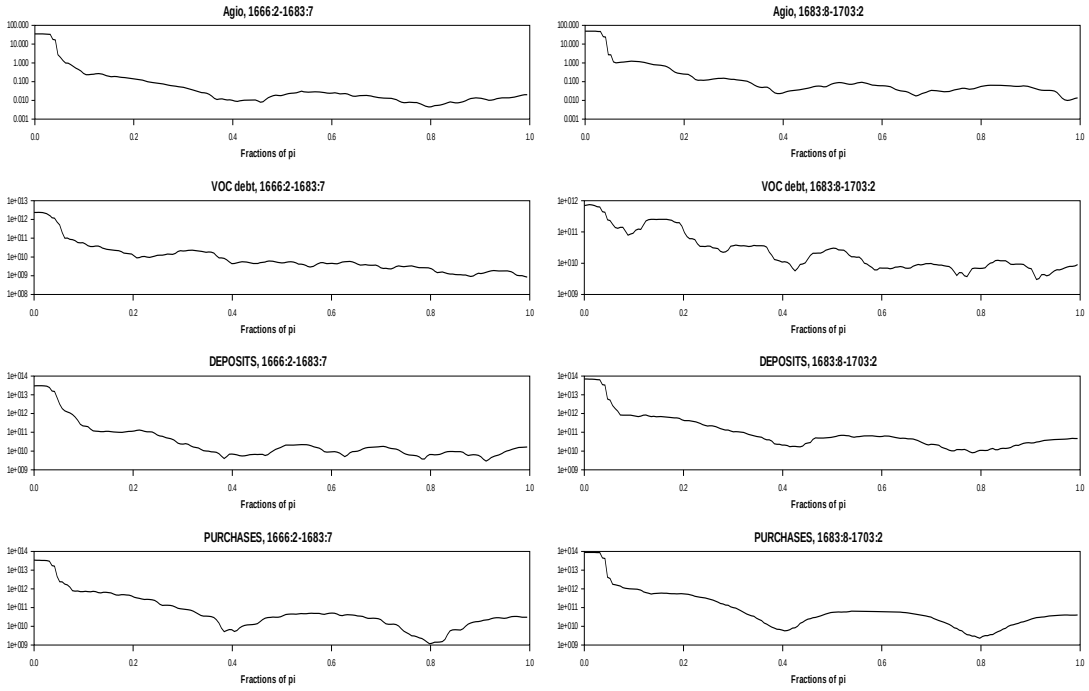
The empirical literature on the founding of the Federal Reserve (see Section 5) emphasizes changes in seasonal patterns for certain macro series around the time the Fed began operations in 1914. With these results in mind, we conducted several exercises to see whether the AWB's 1683 reform resulted in similar changes in the series for balances and the agio. Figure 9 plots monthly means for the agio and the three component series for balances.

Figure 9: Monthly means (percent deviation from annual means)



There is some evidence of modest seasonality in the agio post-1683. Monthly means for deposits display *less* seasonality after the regime change, while VOC debt becomes highly seasonal. There is little evidence of seasonality in the series for purchases, either before or after 1683. Similar evidence on shifts in seasonality are displayed figure 10, which shows estimated spectra for the same four series.

Figure 10: Estimated spectral densities (log scales)



The most striking feature of figure 10 is that the spectrum for VOC balances displays well-defined maxima centered around seasonal frequencies of $\pi/6$, $\pi/3$,and $2\pi/3$ (12, 6-, and 3-month cycles), post-1683. Seasonality for the other series is modest and there are no great differences across subsamples.

Summarizing the results of this section, initial exploration of the data suggests that the post-1683 regime was characterized by higher flows and levels of deposits, somewhat less variable purchases, a higher average agio, and more seasonal and regular borrowing on the part of the VOC.[29] The next section investigates to what extent these observed changes can be attributed to changes in policy.

[29] Available data indicate that the regime change seems to have had virtually no impact on trend inflation. Annual price indices for the Netherlands (van Zanden, 2004) show an average yearly deflation of 0.38% from 1666 to 1684 and 0.30% from 1684 to 1702.

4. The impact of policy changes

To market participants at the time, there was no obvious discontinuity in the function of the AWB after 1683. As before, the bank continued to serve as a trusted settlement service provider and as a (surreptitious) financial intermediary to the VOC. Convertibility of deposits was limited, but money could easily be traded for coin on the open market, much as before. Where then were the efficiency gains associated with the adoption of a fiat standard?

Our answer, in essence, is that placing restrictions on convertibility allowed Amsterdam to partly escape the opportunity costs of a system of exchange based on commodity money (e.g., Sargent and Wallace 1983), as compared to a system with either greater availability of credit, or fiat money. To be certain, some amount of commodity money was essential for the functioning of a 17th-century open economy such as Amsterdam's. A great entrepôt of its day, Amsterdam was where Europe purchased goods from Asia and other points east with silver unearthed in the Americas (de Vries and van der Woude 1997). Over time, Amsterdam also became the center of the European bullion trade.

However, the data shown in Figures 5 and 8 indicate that before 1683, the bulk of the metal backing for AWB deposits rarely entered or left Amsterdam on net. The high cost of withdrawing funds from the bank meant that the principal purpose of this metal was to confer value to the bank guilder. The prospect of seven million guilders' worth of metal simply sitting in the bank's vault must have tempted even the most ardent hard-money advocates.[30] The 1683 reform nudged the AWB's functionality somewhat closer to that of a modern central bank.

[30] How large a sum did this represent? De Vries and van der Woude (1997, 90) put the total stock of coin in the Dutch Republic at around 120 million guilders for the year 1690, indicating that around 5 percent of the Republic's coin stock resided in the bank.

4.1 Credit policy

Before and after 1683, the bank enjoyed certain advantages as lender to the VOC: by virtue of its perpetual nature[31] and its political position,[32] the bank was naturally a stronger creditor to a large multinational operation than other potential seasonal lenders, who were likely to be foreign and in Amsterdam only for the short term. The bank also had advantages as a borrower. The requirement to settle commercial obligations in bank money meant that within Amsterdam, bank balances were more liquid than any other form of debt.

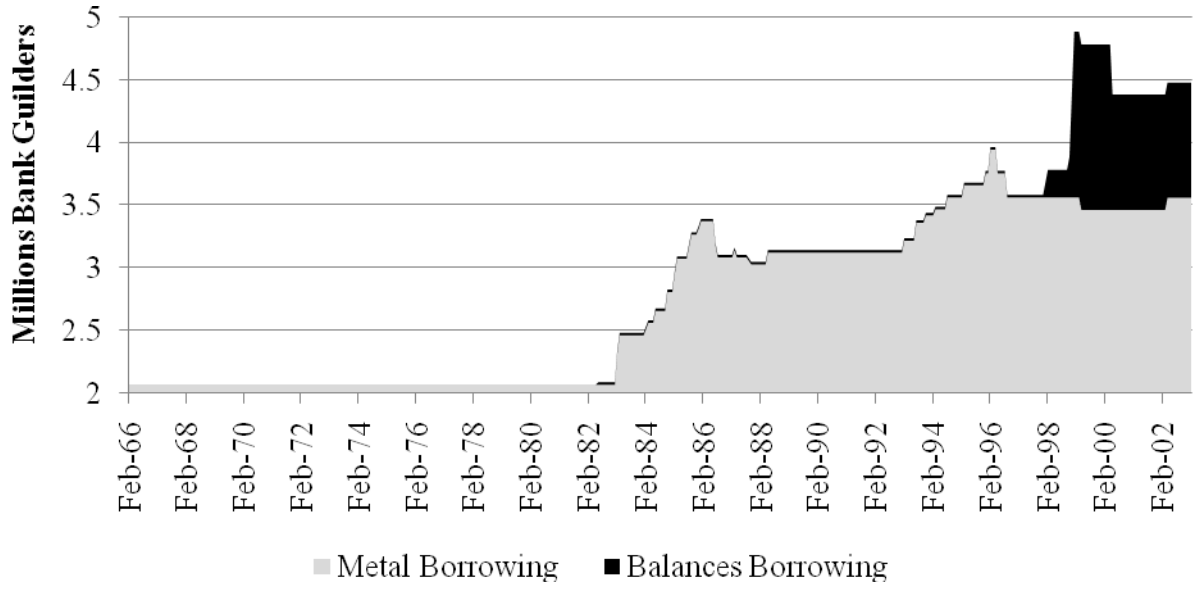
The AWB's early lending activities represented a partial shift to an asset-backed currency. As long as all deposits were convertible, however, the bank was reluctant to extend credit much in excess of its capital position. Either the bank exposed itself to the risk of a run by lowering its metal-to-deposit ratio, or financed its lending from its own capital, or a combination of the two. Alternatively, the bank could slacken its liquidity constraints by imposing higher withdrawal fees as it did in 1672, but this discouraged deposits and imposed costs on market participants. We will now elucidate how the bank lent more frequently with less capital cushion after 1683.[33] To do so requires a discussion of the bank's relationship with the City of Amsterdam.

The bank's activities as financial intermediary were closely constrained by its relationship with the city. Other than VOC, the city was the bank's other major borrower, if borrower is the correct term.[34] Figure 11 shows the evolution of the city's debt over the sample period. In the early 1650s, the city had borrowed 2 million guilders in metal from its bank, and soon afterwards the city stopped paying interest on the loan and never again paid interest on its debt. Figure 11

[31] The 1609 charter of the bank contained no "sunset date." This contrasts with say, the First Bank of the United States, which received a 20-year charter.
[32] During the period we analyze, the AWB was governed by a board of commissioners, comprised of three or four prominent individuals such as former mayors ('t Hart, 2009).
[33] See Appendix B for a formal model of the changeover in the bank's credit operations.
[34] The Province of Holland's debt also appears on the AWB's books but never changes during our sample period.

shows this debt still on the books in 1666 through 1683. In 1683, the city began taking out more metal, in grey, and occasionally paying some of it back, but these metallic loans did not create balances. Loans to the city that did create balances are in black, and those loans do not begin to substantially add to AWB balances until December1698.[35]

Figure 11: Amsterdam Loans Outstanding by Month, 1666-1702



Source: AWB Balance Books, see Appendix A for details.

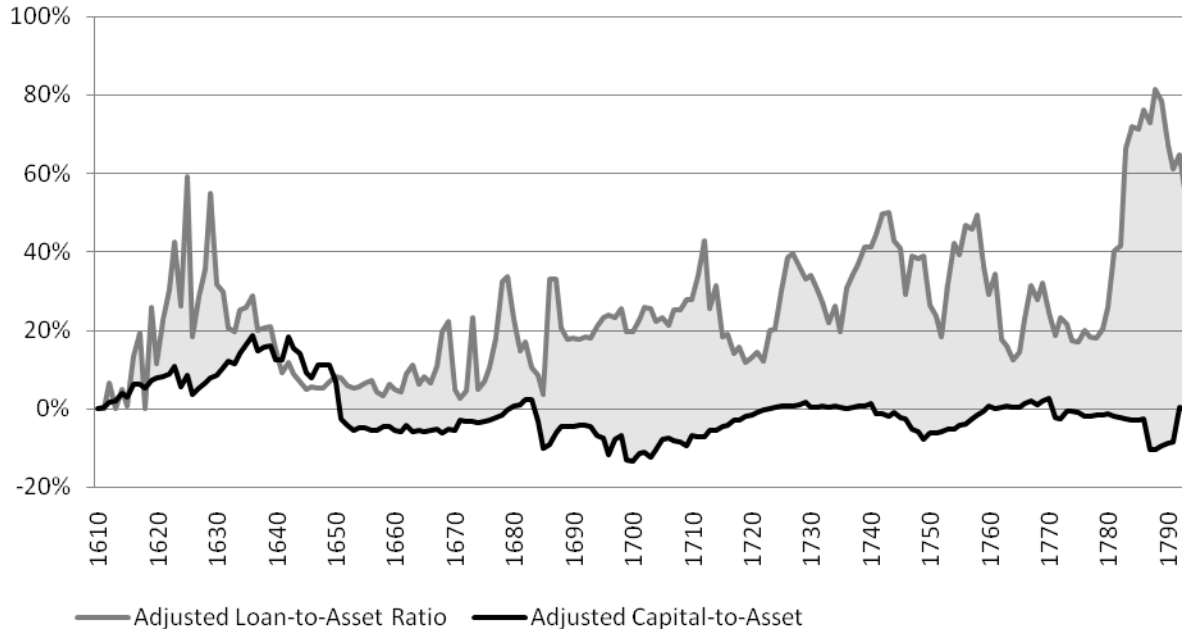
Amsterdam's impact on the AWB is easily missed because the city booked its removal of metal (and its creation of balances) as loans. The city would eventually write off the loans by reducing the bank's capital. This accounting hid periods of negative capital. Figure 12 shows the bank's yearend adjusted capital-to-asset ratio (adapted from van Dillen 1925) from its start in 1610 to the French invasion of 1795. The ratio treats municipal "loans" as capital deductions.

The adjustment shows that the 2 million guilders the bank gave to city in the early 1650s (to build a new city hall) put the AWB into a negative position, and it shows that this era ended when the AWB began to grow capital faster than assets after the Crisis of 1672. Negative capital,

[35] A lone 20,000 guilder balance was created in June 1682.

however, returned after 1683 through the process depicted in figure 11 above. Thereafter, the city took capital during periods of need and then let retained earnings rebuild capital. By 1795, the city had taken 6.5 million guilders from the bank (our calculation). The only indication of this in the traditional series is the bank's 1685 write-off of loans (to the tune of 2.3 million guilders) until book capital neared zero (Willemsen 2009, 85). Limiting the right of withdrawal helped the city take metal and the bank admit (at least to itself) to having no capital.

Figure 12. Adjusted Asset Ratios, 1610 to 1795



Source: Authors' calculations using van Dillen 1925: 701-97, 971-84.

Accounting also obscured the lending picture, so figure 12 plots a loan-to-asset ratio adjusted by us to remove municipal takings and their subsequent write-offs. In the earliest decades, the bank experimented with lending, but then became very conservative during the 1640s and 1650s. Before our regime change, the AWB flirted with periods of increased lending, but only after 1685 (the year the AWB admitted to having no capital) did lending permanently increase to 20 percent or more for most of the next century. The grey background series in figure 12 goes

further by subtracting the adjusted capital-to-asset ratio from the adjusted loan-to-asset ratio to measure overall aggressiveness: leveraged lending (loans not backed by capital) and capital extraction (liabilities not backed by assets). This spread averaged 17 percent in our sample years before receipts (1666 to 1683) and 29 percent for our years after (1684 through 1702).

The annual numbers, moreover, understate the expansion of lending after 1683, for the seasonal nature of VOC borrowing often left little debt at the end of the AWB's fiscal year (January 31). In other words, the yearend numbers miss much of the lending activity presented back in figure 4. It also misses how this lending contributed to the VOC, and the Dutch economy, for it helped fund the outfitting of ships (late August through November) before ships returned from Asia with new goods.

Some idea of this impact can be detected from surviving records of the VOC. De Korte (1984) collected annual VOC balance sheets that give levels at the start of a fiscal year (usually May 31) for assets such as cash, credits, and the inventory of unsold goods; and for liabilities (primarily corporate debt). Better still, three flow variables are also known for the fiscal year: expenditures paid, dividends paid and revenues collected.[36] An OLS estimation reported in Table 4 calculates how these variables correlate with our dependent variable of interest, the amount the VOC borrowed that year from the AWB.[37] Expenditures during a year strongly and positively correlate with borrowing, and suggest a derived demand for AWB loans of 25 percent of VOC expenditures. In contrast, information about that year's sales revenue lacks explanatory power.

[36] All are measured in current guilders, and all are for operation in the Netherlands. Ships at sea and operations in Asia are excluded.
[37] VOC borrowing totals follow the VOC's fiscal year rather than the AWB fiscal year reported in van Dillen (1934, 979-984).

These results agree with the idea that the VOC was borrowing to outfit ships before the year's fleet returned from Asia.[38]

Table 4. VOC Correlates to AWB Lending, 1666 to 1702

Dependent Variable: AWB LENDING in Bank Guilders

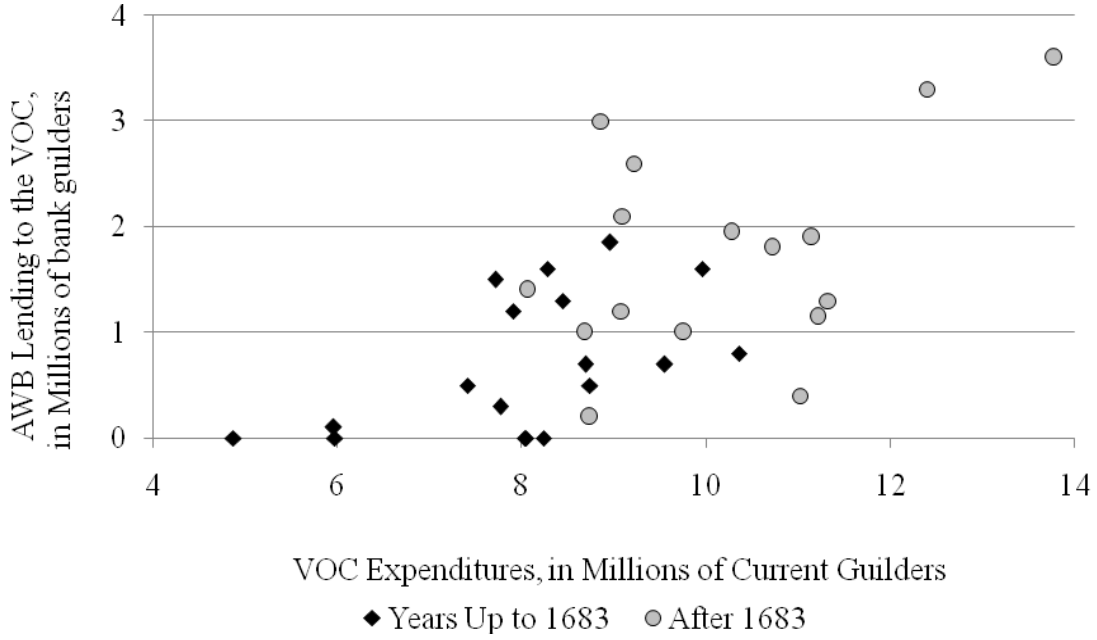
Independent Variables in Current Guilders.

	Coefficient	*t*-Statistic	*p*-value
Flow Variables			
1. EXPENDITURES	0.243575	2.854951	0.0079
2. DIVIDENDS	0.086721	0.588119	0.5610
3. SALES	0.001038	0.013216	0.9895
Year Start Levels			
4. INVENTORY	-0.057136	-1.495904	0.1455
5. CASH	-0.158387	-0.823348	0.4170
6. CREDIT DUE	-0.402999	-1.614495	0.1172
7. TOTAL DEBT	-0.006557	-0.141776	0.8882
N= 36		Adjusted R-squared	0.365084
		Durbin-Watson	1.778873

Given the relationship between AWB lending and VOC expenditures, the economic benefit from expanded seasonal lending should have been expanded investment in VOC expeditions. To visually check this, Figure 13 plots for each of our sample years VOC expenditures on the horizontal and AWB lending to the VOC on the vertical. While noisy, more expenditures do seem to follow an expanded credit policy by the AWB: the series' simple correlation is +0.56.

[38] We should note that the regime change of 1683 does not by itself explain the end of multi-year lending by the bank to the VOC, for that change coincides with structural changes in the VOC's corporate debt following from the crisis of 1672 (de Korte 1984, 66). At the start of our sample, 1666, the VOC's long-term debt was in the form of bonds callable at par by either debtor or creditors. The VOC had a program of retiring long-term debt in 1670 until the crisis in 1672, and the lack of borrowing in Figure 4 for those years is evident. During the 1672 crisis, the VOC suspended the call option, and in the years that followed restructured its debt to avoid this problem. First, the VOC began offering short-term anticipations that gave a senior claim on auction proceeds from the next fleet to arrive. Then the company issued long-term debt without creditor call options. The bubble of multi-year borrowing (figure 4) from 1676 to 1682 appears to have helped the VOC finance holdout redemptions until new lenders could be found.

Figure 13. AWB Lending and VOC Expenditures, 1666 to 1702



Sources: See Appendix A.

Unfortunately we do not know exactly where bank loans fit into the VOC's capital structure, e.g., the seniority of bank loans relative to other kinds of debt. But the VOC's frequent borrowing post-1683 suggests that the ready availability of bank credit contributed to the company's ability to manage its cash flows.

4.2 Monetary policy

The new regime also altered constraints on monetary policy in ways that encouraged market discipline and AWB intervention. Taking markets first, high withdrawal fees fostered an instability in the value of money common to many commodity money regimes. The agio could range as low as 3.5 percent—1.5 percent below its statutory value[39]—without any change in underlying fundamentals, and apparently without triggering large withdrawals (see figures 3 and 5).

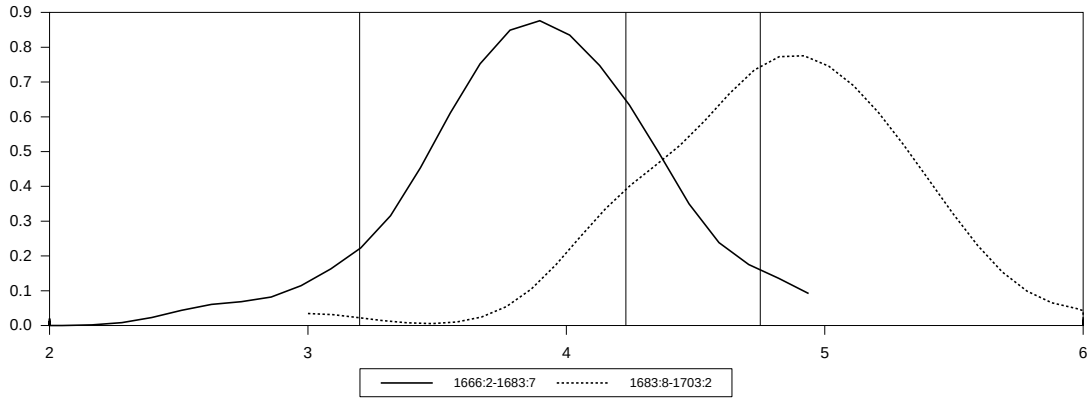
[39] Note that the statutory agio varied by coin. For example, the silver dukaat had a statutory agio of 4.14 percent, and the silver rijder had a statutory agio of 5.00 percent (Polak 1998, 73-4).

A stylized example may be helpful in illustrating how. Start with a minting ordinance that assigns a coin a legal value of exactly one current guilder in general circulation and a value of $x < 1$ bank guilders when deposited in the AWB, where $\alpha = (1/x) - 1$ is the implied statutory value of the agio. If the bank charges $w > 0$ at withdrawal, then the (steady-state) market agio, *a*, can lie anywhere in the interval[40]

$$\left(\frac{1+\alpha}{1+w} - 1, \alpha \right). \qquad (1)$$

The 1683 decrease in *w* increased the agio's lower bound $\underline{a} = (1+\alpha)/(1+w)$, so low agios now encourage more outflows than before. E.g., if $\alpha = 4.75\%$, then a reduction in *w* from 1.5% to 0.5% contracts the interval (1) from $(.032,.0475)$ to $(.0423,.0475)$. These two intervals, along with the empirical densities of the agio, are shown in figure 14.[41]

Figure 14. Estimated densities for the agio



The figure shows that the agio often moved outside the steady-state bounds in (1), particularly post-1683. Historical accounts (e.g. ,Van Dillen 1964b, 404) assert that after 1683, the bank countered such deviations through open market operations. But van Dillen, Mees, and others are

[40] After 1683, the cost of a withdrawal would include the market value of a receipt. Hence in practice the agio could fall slightly below the lower endpoint in (1) without violating no-arbitrage.
[41] Estimated densities are histograms, smoothed with Gaussian weights. Outlier values are not shown.

mute regarding the manner and extent of these operations. Our reconstruction of master account transactions points to the AWB buying and selling bullion rather than coin. To increase (decrease) the agio, the AWB would sell (buy) bullion below (above) the market price and decrease (increase) the quantity of bank guilders.

Why trade bullion rather than coin?[42] Trading coin would have violated the bank's fundamental assignment of respecting and maintaining the mint ordinance values of coins. In contrast, bullion could be traded without necessarily upsetting the circulation of coins at all. To see this, let our one current guilder (*x* bank guilder) coin from the preceding paragraph contain *b* ounces of silver. Also, add mints that offer to convert silver to coin, collecting a fraction σ of the silver as seigniorage. If the market agio on bank money is still *a*, then the steady-state price of silver γ (expressed as bank guilders per ounce) lies in the interval[43]

$$\left(\frac{1-\sigma}{b(1+a)}, \frac{1}{b(1+a)}\right). \tag{2}$$

in order for the coin to circulate at face value, the mint offers to buy silver at the lower price and "sell" (dispense coins) at the higher price. The bank had to take these limits into account in its open market operations.

The 1683 reform eased these constraints. Receipts allowed the AWB to purchase existing options to withdraw coins, so the stock of potentially circulating coins could be reduced without the bank offering an unofficial price. Lower fees also allowed the AWB to more easily "tighten" by selling bullion. To see the effect of lower fees on the range of bullion sale prices, insert the

[42] Why not trade in government debt? Holland had no secondary market for sovereign debt in this era (Gelderblom and Jonker 2010).

[43] I.e., γ lies in an interval formed by the mint price of the coin and the mint equivalent of the coin, converted to bank guilders at the market agio. See e.g., Redish (1990), Sargent and Smith (1997), or Sargent and Velde (2003) on the derivation of expression (2).

lower bound for the agio $(\underline{a})$ in equation 1 into equation 2 to get the steady-state price of silver γ when the agio is at its steady-state minimum:

$$\left(\frac{1-\sigma}{b\left(\frac{1+\alpha}{1+w}\right)}, \frac{1}{b\left(\frac{1+\alpha}{1+w}\right)} \right). \tag{3}$$

The decrease in *w* decreased the lower bound $\underline{\gamma} = (1-\sigma)(1+w)/[b(1+a)]$ in (3), allowing the AWB to more easily sell bullion at a price above the mint's purchase price.

Receipts also eliminated the need for coin-specific premia by ending cross-coin substitution. To see why, assume two coins with value-metal pairings of (x_1, b_1) and (x_2, b_2). Under the traditional general collateral rule, coin 1 needs a fee $w_1 \geq \max\left(\frac{b_1}{b_2}\frac{x_2}{x_1} - 1, 0\right)$ to avoid coin-to-coin arbitrage. The receipt system avoided the problem by using specific collateral. All together, lower fees simultaneously tightened the agio $(\uparrow \underline{a})$ and eased the bank's ability to sell bullion $(\downarrow \underline{\gamma})$ when the agio was low: near $\underline{a}$. Note also that the effect is asymmetric, for reducing fees does not alter $\bar{a}$, or $\bar{\gamma}$ when the agio is high.

Returning to the data, the integrated series on purchases and deposits, graphed in Figure 8, provide a narrative to the bank's open market activity. Before 1683, open market activity seems to have had a defensive character. "Reserves" of metal were accumulated by large purchases at favorable times. Purchased metal was rarely drawn down through sales, the chief exception being the years 1680-83, by which point virtually no coin was being deposited (see Figure 5) and cumulated deposits were approximately zero (Figure 8). After 1683, infrequent spikes in purchases continue as before, but these are followed by lengthy periods over which the bank is a net

seller of metal (1685-87, 1691-94, 1695-98, 1699 onward). By then the bank apparently felt more comfortable parting with its metal purchases than it did before the 1683 reform.

Months with the largest purchases and sales are cataloged in Table 5 below.

Table 5. Potential Large Open Market Operations

5a. Bullion Purchases/ Sales of Bank Money

Month	Size (guilders)	Size (% total balances)	Agio	Compared to Agios +/- 12 months
May-68	1,437,506.25	24%	*4.00*	Highest
Aug-70	815,231.20	12%	*4.72*	High
Sep-70	1,415,986.48	18%	*4.90*	High
Dec-79	994,726.08	17%	*4.47*	Highest
Feb-80	807,539.45	10%	4.44	High
Oct-85	1,909,653.70	29%	5.13	High
May-94	1,022,275.45	9%	4.69	Low
Oct-98	706,765.30	5%	*5.00*	High
Nov-98	899,359.70	6%	*5.19*	High

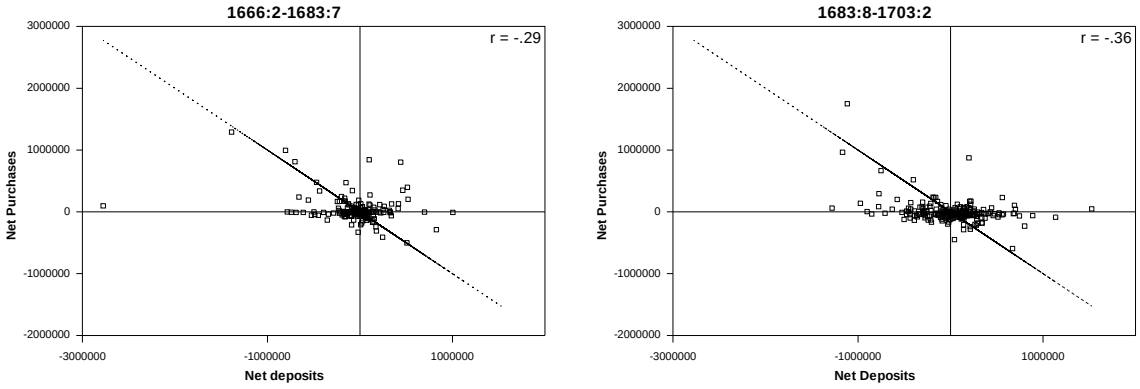
5b. Bullion Sales/ Purchases of Bank Money

Month	Size (guilders)	Size (% total balances)	Agio	Compared to Agios +/- 12 months
Nov-67	340,681.90	5%	3.19	Lowest
Sep-70	573,082.22	7%	*4.90*	High
Nov-75	308,633.05	6%	*3.53*	Low
Nov-77	409,548.10	7%	*3.75*	Low
Nov-81	501,789.50	7%	*3.63*	Low
Dec-86	612,842.55	6%	*5.25*	High
May-91	450,312.75	4%	5.25	Low
Nov-94	300,312.27	2%	4.75	Low

Notes: Operations are classified as "large" if they are more than 3 standard deviations above the series mean. Agios with italic font are same month; normal font is closest month available.

A case-by-case examination indicates that these exceptional transactions almost always leaned against the wind: metal was purchased during periods of high agios, and vice versa.[44] In addition, the AWB's large purchases are often approximately offset by large deposit outflows, and vice-versa for large sales. Net purchases and net deposits almost exactly line up on a negatively sloped 45º line for many high-value observations, both before and after 1683 (figure 15). This pattern of activity resembles the sterilization operations of modern central banks, in which a large movement in one source of funds is offset with an open market operation in the opposite direction (Hamilton 1997).

Figure 15: Net Purchases versus Net Deposits (Bank Guilders)



Source: Appendix A.

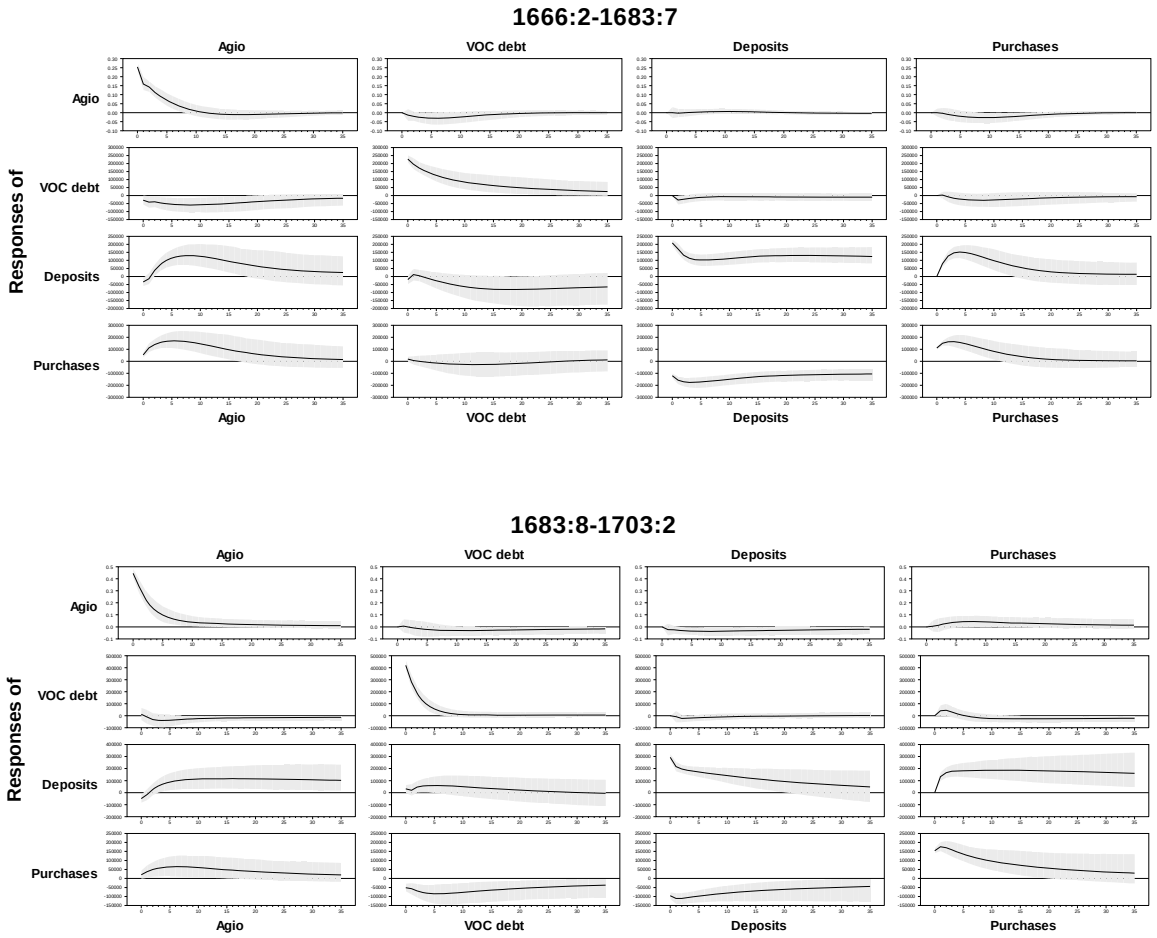
Offsetting of purchases and balances is confirmed in a more formal exercise in which a vector autoregression was fit to the four principal data series (the agio, VOC debt, cumulated deposits, and cumulated purchases).[45] The VAR was fit over a sample that includes all available observations on balances, except the two outlier episodes in 1672 and 1693. The specification

[44] Exceptions are the large bullion purchase in May 1994 and sales in September 1670 and December 1686; however, these transactions represent partial unwindings of transactions in the opposite direction during the same or previous month.

[45] Note however that the linearity of the VAR means that by definition it cannot capture the asymmetry between sales and purchases described above.

includes monthly dummies and 2 lags.[46] Stationarity of the model coefficients across the 1683 break is strongly rejected by a classical likelihood ratio test (p<.001).[47] 36-month impulse responses from the two VARs (pre- and post-1683) are graphed in figure 16. Responses shown are for a Cholesky decomposition of the forecast error variance-covariance matrix with the agio first in the ordering. [48]

Figure 16. Sample impulse responses



[46] The 2-lag specification is chosen under the Akaike, Hannan-Quinn, and Schwarz criteria; sequential likelihood ratio tests choose more lags.
[47] Stationarity of coefficients is also rejected under the Akaike and Hannan-Quinn criteria; however stationary is favored under the Schwarz criterion.
[48] The graphs depict posterior mean responses under a diffuse prior, together with ninety percent posterior error bands.

Noteworthy in figure 15 are the persistently negative responses of purchases to shocks to deposits, both before and after 1683, consistent with the idea that the bank's open market operations worked to smooth short-term fluctuations in the money stock. Shocks to deposits are less persistent after 1683, perhaps reflecting greater efficacy of the bank's operations after the transition. Post-1683 shocks to VOC balances also induce sales of metal by the bank, suggesting that these fluctuations were at least partly sterilized. Also of interest in figure 15 are the responses of deposits and purchases to shocks to the agio. Both have a persistently positive response (after a month's delay in the case of deposits), implying that the bank added funds to the market when bank funds became unexpectedly scarce, and drained funds when money was plentiful.

Summarizing this section, our analysis of AWB balances suggests that the bank conducted open market operations throughout the sample period, with some purchase operations in particular being quite aggressive. There is a strong negative correlation between shocks to deposits and shocks to purchases, suggesting that the motivation for many these operations was to smooth fluctuations in the money stock. The 1683 regime change both encouraged deposit flows and eased arbitrage constraints on the bank, allowing the AWB greater latitude to sell off purchased metal.

5. Connections to the literature

The above analysis invites comparison to similar analyses of U.S. macro time series before and after the 1913 founding of the Federal Reserve. Numerous studies (e.g., Clark 1986, Miron 1986, Mankiw, Miron, and Weil 1987) have documented that U.S. interest rates become extremely persistent and virtually aseasonal starting in 1914, while monetary aggregates display increased seasonality. These changes are often attributed to Federal Reserve policies, especially a quasi-pegging of short-term interest rates through the opening of the discount window.

Figures 5 and 6 show that comparable shifts do not occur around 1683, except for increased seasonality of VOC loan balances. Lack of change in seasonal patterns for the other two components of the money stock is consistent with the more evolutionary nature of the 1683 policy change, and the AWB's restriction of seasonal lending to a single counterparty.

The VAR analysis reported in Canova (1991, 700-701) (see also Tallman and Moen 1998) finds that before 1914, external shocks to high-powered money are highly causal for the U.S. domestic money stock, but that this same effect is greatly diluted after 1914. We cannot fully replicate Canova's exercise due to data limitations (observations on macro series such as output and prices are unavailable), but figure 15 displays a similar pattern to the pre-1914 U.S. case: favorable shocks to the agio (to the extent these originate abroad) have a persistent positive impact on money. In contrast to the post-1914 U.S. experience, however, this pattern attenuates somewhat but does not disappear after 1683.

Aspects of the AWB's operations are reminiscent of modern currency boards. E.g., the Hong Kong Monetary Authority has standing offers to sell Hong Kong dollars at a unit price of US $0.129 and to repurchase its money at a 1.27% lower price, roughly matching the AWB's bid-ask spread. The receipt system evidently allowed the bank to function with a lower "backing ratio" of external assets to central bank money than do modern currency boards, which often operate with a backing ratio of 100 percent or more.

Currency boards can be effective in stabilizing monetary value, but a commonly cited defect is their inability to ward off banking crises (Chang and Velasco 1999, 2000). Yet no widespread banking crises occurred in Amsterdam during the period we analyze. This is perhaps due to Amsterdam's reliance on a web of informal trade credit and personal guarantees (bills of exchange) for business financing, rather than deposit banks. And, as has been demonstrated, the

AWB could and did indirectly ease credit conditions by providing financing to the largest enterprise in the economy.

In the eighteenth century, Amsterdam expanded its credit markets at the cost of increased financial fragility. A system of "acceptance credit" developed, under which bills of exchange were guaranteed against default ("accepted") by one of a small number of prominent local merchants, lowering the chances of a single default but concentrating credit risk in a small number of counterparties. A full-fledged financial panic developed in 1763 after the failure of a prominent acceptance house; the AWB could do little in response (Schnabel and Shin 2004).

6. Epilogue and conclusion

The innovations of 1683—the move to a de facto fiat standard—made it possible for the Bank of Amsterdam to conduct credit and monetary policy on terms comparable to modern central banks. Our analysis shows that this change allowed the bank to lend with little if any capital, and to counter money outflows through sales of its metal stock. The weakness of this system lay in its dynamics: having no natural endowment of precious metal, Amsterdam's liquidity hinged on an uninterrupted external supply of silver. Following the outbreak of the Fourth Anglo-Dutch War in 1780, silver inflows were curtailed and the bank's loans to the East India Company sharply expanded, even as chances of their repayment diminished (see figure 12). Erosion of confidence led to a sharp depreciation of the bank guilder, and by 1790 the world's first great experiment with fiat money largely had come to an end (van Dillen 1934, 112-115).

Does the Amsterdam experience offer any insights for monetary policy today? Our answer is yes, precisely for the reason that, as first movers, the masterminds of the 1683 reform could construct a fiat money scheme unburdened by any modern ideas about central banking. The re-

sulting system, conceived in this "state of nature," emphasized straightforward policies adapted from earlier experience under a commodity standard. In monetary terms, the bank acted to increase the market value of its liabilities, i.e., the agio, in terms of externally valued collateral. In credit terms, the bank lent in restrained amounts, though on generous terms, to a blue-chip (and government-sponsored) borrower. Profits from these activities were quietly returned to the bank's sponsor, the City of Amsterdam.

Simplicity was the hallmark of the bank's operations. There was little need for policy statements, inflation targets, or exit strategies. Paradoxically, secrecy also played a role: while the general character of the bank's operations was public information, its financial condition was not. Many contemporary observers, Adam Smith included, believed the AWB to possess a stock of metal far in excess of its actual holdings, and the bank's true condition was revealed only after its 1790 collapse. Until that point, the managers of the world's first big fiat money factory seem to have absorbed a lesson familiar to today's high-tech mavens: for a virtual good, reputation is everything.

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