Responding to a Shadow Banking Crisis: the Lessons of 1763

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Stephen Quinn
Department of Economics
Texas Christian University
Box 298510
Fort Worth, TX 76129
s.quinn@tcu.edu
817.257.6234

William Roberds
Research Department
Federal Reserve Bank of Atlanta
1000 Peachtree St., N.E.
Atlanta, GA 30309
william.roberds@atl.frb.org
404.498.8970

Abstract

In August 1763, northern Europe experienced a financial crisis with parallels to the 2008 Lehman episode. The 1763 crisis was manifested in a loss of liquidity of acceptance loans, a form of securitized credit resembling modern asset-backed commercial paper. The crisis began with the failure of a major securitizer ("conduit") in Amsterdam, and quickly spread to neighboring markets. The central bank at the hub of the crisis, the Bank of Amsterdam, responded by broadening the range of acceptable collateral for its repo transactions. Using archival data on the Bank's operations, we show 1) that the 1763 crisis was proportionately more severe than that experienced in 2008, 2) the Bank's emergency liquidity infusion likely prevented the failure of two other major securitizers and provided indirect benefits to other market participants. While the underlying themes seem to have changed little in 250 years, the modest scope of the 1763 liquidity intervention, together with the lightly regulated nature of the eighteenth century financial landscape, provide some informative contrasts with events of late 2008.

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1. Introduction

The 2008 Lehman bankruptcy gave rise to two unlikely phenomena: a banking crisis in which the liquidity of bank deposits was rarely called into question, and a collection of policy interventions that rescued institutions outside the traditional regulatory safety net.

The Lehman crisis was not manifested as runs on banks (with some rare exceptions such as Northern Rock) but as the dysfunction of markets for certain types of securities. Many of the affected securities were the products of the shadow banking sector, a lightly regulated group of nonbank institutions (Pozsar et al. 2010) that until the disruptions of 2007-8, had been able to transform illiquid cash flows into financial claims with bank-deposit-like liquidity and "information-insensitivity" (Dang et al. 2009).

The shadow banking superstructure began to totter in August 2007, and threatened to collapse with the September 2008 failure of Lehman Brothers. The prospect of a worldwide financial meltdown provoked an unparalleled response, as banks and shadow banks alike were shored up through aggressive policy actions. Arguably the most salient feature of these policies was the raw magnitude of public-sector liquidity they created (Allen and Moessner 2011), with central bank balance sheets increasing to unprecedented multiples of their pre-crisis size.

Would a different pre-crisis regulatory environment have increased market resiliency (e.g., Acharya et al. 2010, Gorton and Metrick 2010)? It is hard to answer without verifying the ubiquity of shadow bank fragility. What if governments and central banks had displayed a lesser response to the Lehman failure? The counter-factual is difficult to construct (see e.g. McAndrews et al. 2008, Adrian et al. 2010, Fleming et al. 2010) without some confirmation of how a run propagates through the shadows. History helps answer these "what ifs," so this paper goes to the Amsterdam Crisis of 1763 to find a precedent that is outside the Anglo-American tradition. In doing so, we follow Schnabel and Shin (2004) by drawing parallels between pre-Napoleonic Continental banking institutions, and the shadow banking structures of today.

Why late eighteenth-century Amsterdam? Because it was replete with merchant banks offering securitization services in a way analogous to, but not identical to modern issuers of asset-backed commercial paper. To enhance credit and liquidity, the Dutch substituted a borrower's obligation

with a debt guaranteed by the merchant bank. The borrowers were located all over the European trading world, but the credit hub was Amsterdam, so credit risk was concentrated there. The process also created a maturity mismatch, so the typical Dutch merchant bank financed itself with new debt before the original borrowers were paid. Dependence on debt rollover made Amsterdam in 1763 as vulnerable to aggregate shocks as New York was in 2008.

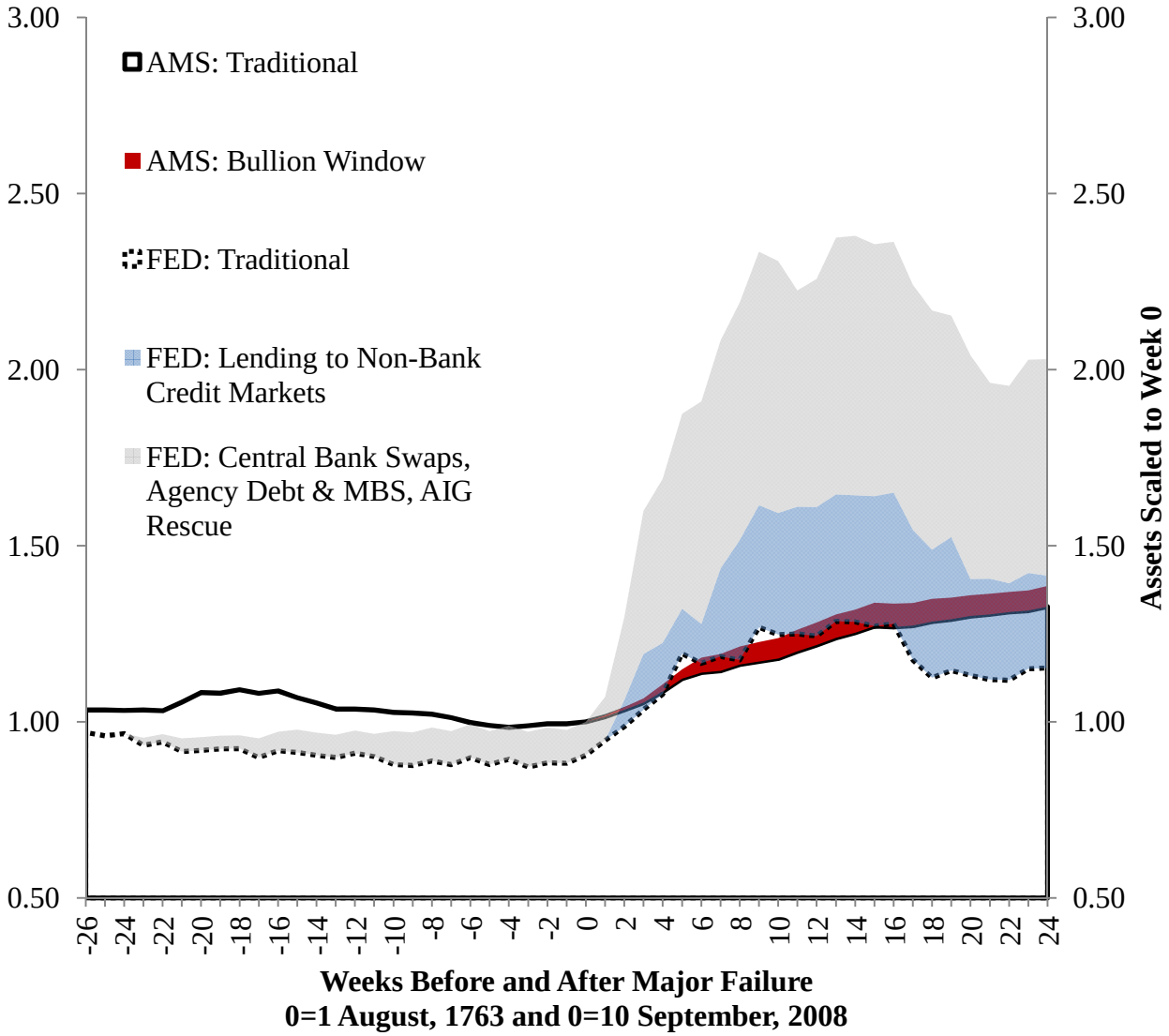
In August 1763, the Lehman-like failure of the banking house *Gebroeders de Neufville* made creditors reluctant to purchase new debt from surviving banks. Our investigations indicate that the resulting shadow run was proportionally greater than that experienced in 2008. To measure the run, we have reconstructed the weekly flow of funds into and out of accounts, reminiscent of asset-backed commercial paper (ABCP) conduits, maintained by the eight largest merchant banks at the Bank of Amsterdam (also the Bank). Large merchant banks were often obliged to use the Bank to settle their debts, called bills of exchange, but light regulation otherwise meant that the Dutch banks did not hide their trading activity. Rich archival data and straightforward financial architecture allow us to reconstruct the portion of the panic that occurred through the Bank's accounts.

A second parallel is in the Bank of Amsterdam's response to the crisis. As in 2008, access to central bank liquidity was expanded on an ad hoc basis. Differently, this expansion was quite narrow in scope. The ad hoc intervention worked through the Bank's repo facilities to broaden the set of assets eligible for repo to include silver bullion. Liquidity also expanded via the traditional channel of repo transactions with trade coins.

Figure 1 compares the expansion of the Bank of Amsterdam's balance sheet in 1763 to the Federal Reserve's in 2008-9. In each case, the balance sheets are scaled to the start of the crisis and broken down by asset class. For the Federal Reserve, the breakdown includes traditional assets (securities purchases), direct lending programs, and liquidity swaps with foreign central banks. Figure 1 also plots assets of the Bank of Amsterdam acquired by traditional channels and by its ad hoc bullion window. The comparison shows that the Bank of Amsterdam's bullion window and its traditional response were comparable in timing, but modest in scale, relative to the Fed's balance sheet expansions. The aggregate increase in liquidity was a "mere" 40 percent over six

months, perhaps more impressive when one considers that the Bank did not operate a traditional discount window or engage in transactions with other central banks.

Figure 1. Weekly Central Bank Assets in 1763 and 2008



Sources: Federal Reserve and Stadsarchief Amsterdam 5077

The bullion window accounts for a relatively small proportion of the Bank's post-crisis balance sheet, but the micro evidence shows that this liquidity channel had disproportionately large ef-

fects. Our new data set tracks liquidity creation by bank, and examination of this data shows that the bullion window likely prevented the failure of at least two additional large merchant banks. In this way, Amsterdam avoided further major bank failures within Amsterdam and avoided too-big-to-fail bailouts. It is noteworthy that this balance was achieved despite Amsterdam being more vulnerable to a crisis than a modern system: financial "firebreaks" such as central counterparties, deposit insurance, and a discount window were completely lacking.

As a precedent, the Crisis of 1763 confirms the model of a shadow bank as a financial firm that has to roll over its financing before the backing assets mature. Shadow runs are the sudden inability to sell new debt, as arrangements designed to make claims money-like fail. The history opens potential explanations for the ascent of modern shadow banking, for the Dutch system evolved in response to demand for securitization rather than to avoid regulation. Finally, the story shows that a shadow run was partially alleviated with aggressive repurchase facilities but without explicit bailouts or too-big-to-fail guarantees.

The rest of this paper is organized as follows. Section 2 reviews related literature. Section 3 discusses banking institutions in eighteenth century Amsterdam. Section 4 discusses the collateral shocks that preceded the crisis and section 5 discuses its outbreak. Section 6 presents empirical evidence on the severity of the crisis, and section 7 analyzes policy responses. A final section concludes.

2. Related literature

There is rich historical literature on the Panic of 1763, with contributions by Büsch (1797), Soetbeer (1855), Sautijn Kluit (1865), Dillen (1922, 1931), Skalweit (1937), Henderson (1962), and Spooner (2002), among others. The analysis below relies on these works, and especially on the monograph of Jong-Keesing (1939), both for historical narrative and as guides to primary sources.

The historical literature is synthesized by Schnabel and Shin (2004), who also propose a theoretical model of contagion effects stemming from Neufville's failure. Our analysis complements

theirs, in that we measure how the panic hit other banks and how the Bank of Amsterdam's response was able to limit the outbreak of contagion within the Amsterdam market.

Flandreau and Ugolini (2011) investigate a similar crisis and response story for London in 1866. In England, the failure of a large bank caused shadow banks (called bill brokers) to suddenly become unable to finance international acceptance credit. The Bank of England responded by rapidly expanding liquidity (Flandreau and Ugolini 2011, 36-7). Unlike Amsterdam, however, the English banks did not necessarily settle bills at their central bank, so the Bank of England accounts did not double as conduits. In Amsterdam, we are able to reconstruct both lender of last resort funding and the obligations pressing on shadow banks.

3. Shadow banking in 1763

Financial activity in late-eighteenth century Amsterdam was dominated by a group of merchant banking firms. In contemporary parlance, these firms were known simply as *banquiers* or "bankers" (Jong-Keesing 1939, 69). Bankers were proprietary firms that dealt in trade goods and that also provided financing to other merchants. These firms were not deposit banks in the English tradition; deposit-taking was viewed as an excessively risky, downmarket source of funding. Aversion to deposits was famously crystallized in a clause of the partnership contracts of Amsterdam's most prominent bank, *Hope en Compagnie*: "the business of this firm will be restricted to matters of commerce and commissions, and it will not engage in negotiations relating to deposited funds, or similar transactions" (Jong-Keesing 1939, 69; Buist 1974, 37).

Since deposits were scarce, financial intermediation was accomplished through a securitization scheme known as the acceptance loan (*acceptcrediet*). The building block of the acceptance loan was an instrument known as the bill of exchange. Somewhat resembling a modern check, a bill of exchange transaction involved a minimum of three actors: a drawer, a drawee, and a beneficiary (see e.g., Schnabel and Shin 2004, 935-939). The bill would be created by the drawer, who would instruct the drawee to pay the beneficiary a certain sum, at a fixed place, at some future date. The drawee would indicate his intention to pay the bill by signing or "accepting" it. A beneficiary could also transfer the bill to a fourth party by endorsing it over.

3.1 Acceptance loans and conduits

In an acceptance loan transaction, the lender was the drawee of a bill, typically a merchant banker in a prominent commercial city such as Amsterdam. To make the arrangement work, the banker had to "close the loop" of obligations created by the drawing of a bill, i.e., to somehow arrange for repayment from the drawer. Table 2 below presents a stylized example of one common technique for constructing an acceptance loan. [1]

For ease of comparison, consider first the interaction of four agents in the context of a modern, ABCP type of arrangement (see, e.g., Brunnermeier 2009, Acharya, Suarez, and Schnabl 2010, Kaperczyk and Schnabl 2010). There are three periods: 0, 1, and 2. Agent *D* is a debtor who borrows for two periods, *C1* is a creditor who lends early, *C2* is a creditor who lends late, and *B* is a banker-conduit who creates secondary debt and provides credit/liquidity enhancement. Table 1 presents a stylized version of ABCP, in which debt issued by *B* is "backed" by cash flows from the activities of *D.*

Table 1: stylized ABCP conduit, 2008

Period 0:	(a) *D* creates and sells an ASSET to *B* (b) *B* creates and sells ABCP1 to *C1*
Period 1:	(a) *B* creates and sells ABCP2 to *C2* (b) *B* repays *C1* for ABCP1
Period 2:	(a) *D* repays *B* for ASSET (b) *B* repays *C2* for APCP2

A critical feature of the story, and the source of *B*'s profit, is that the ABCP issued by *B* has credit and liquidity guarantees that make it into a palatable investment for *C1* and *C2*. As became clear in 2007-2008, however, *B*'s guarantee to *C1* may depend on rollover funding from *C2* (Kaperczyk and Schnabl 2010).

[1] The bill of exchange was a flexible instrument that allowed for many variations in the type of credit scheme that could be constructed. E.g., Schnabel and Shin (2004, 935-940) present a more complex example of an acceptance loan, in which the ultimate borrower is the beneficiary of the bill.

Let us now consider how a largely equivalent arrangement would have been constructed in Amsterdam in 1763 (to do so we need an extra period and a second location). In this example, *D* would typically be a merchant operating in a remote market (e.g., Hamburg) and *B* would be an Amsterdam banker. *C1* and *C2* are bill investors, residing in Hamburg and Amsterdam respectively, in this stylized example. An acceptance loan from *B* is used to "securitize" a profitable activity by *D*.[2]

Table 2: stylized acceptance loan, 1763

	In Hamburg	In Amsterdam
Period 0:	(a) *D* draws BILL1 on *B* (b) *D* sells it to *C1* *C1* travels to Amsterdam	
Period 1:		(a) *B* accepts BILL1 (b) *B* draws BILL2 on *D* (c) *B* sells BILL2 to *C2* *C2* travels to Hamburg
Period 2:	(a) *D* accepts BILL2	(b) *B* settles BILL1 with *C1*
Period 3:	(a) *D* settles BILL2 with *C2*	

As with the modern ABCP arrangement, credit and liquidity guarantees by *B* play a big role. *C1* is willing to take a bill drawn by *D* because he thinks it will be accepted by *B*. Similarly, *C2* is willing to take the bill drawn by *B* on *D* because he knows that *B* is liable if *D* cannot pay.

Also like the ABCP arrangement, the acceptance loan scheme is vulnerable to disruptions in rollover funding: *B* may have trouble keeping promises to *C1* if he cannot sell a bill to *C2*. Clearly, such disruptions are more prone to occur in times of aggregate shocks: if *B* has guaranteed many borrowers such as *D* with correlated credit risk, doubts may arise about *B*'s ability to make good on his guarantees.

[2] Classically, acceptance loans were collateralized by commodity flows in the opposite direction of the bill obligation. But, depending on the risk appetites of the individual counterparties involved, they could also be used for simple speculation on exchange rate movements (and/or local precious metal prices). In the example, *D* could use a bill drawn on *B* to go short guilders (in Amsterdam) & take a long position in say, local money in Hamburg or Berlin.

One source of such aggregate shocks would be movements in exchange rates. Note that in contrast to Table 1, the borrower *D* in Table 2 is essentially shorting one currency (the guilder in Amsterdam) to take a long position in another (the thaler in Hamburg). Indeed, one popular use of acceptance credit was to fund speculation in exchange rates. This feature of acceptance loans increased their susceptibility to market risk.

More critical than market risk, however, was another vulnerability that does not show up under the modern ABCP arrangement: if *C1* buys a bill from *D*, and *B* then declines to accept ("protests") the bill, then *D* loses the funding of the bill and becomes subject to liquidity risk. When bankers protest bills to conserve their own liquidity, they can force parties such as *D* into bankruptcy, in which case a creditor such *C1* has (at least temporarily) lost his principal on the first trade.[3] The acceptance credit (or bankers' bills) common in later Anglo-American systems either eliminated protest risk by having the bank accept the bill *before* the drawer sold it or reduced protest risk through instruments of provisional acceptance such as a banker's letter or a correspondent's assurance.[4]

Moreover, *C1* could not escape principal risk by selling ("discounting") the bill. "Holder in due course" provisions of the prevailing commercial law meant that anyone transferring a bill to another party (as often happened in organized bill markets) retained contingent liability if the drawee could not pay (Schnabel and Shin 2004, 938-939). The limited extent of deposit banks meant that bills sometimes circulated as money in large-value commercial transactions, especially after acceptance by a major bank. The attendant risks, stemming from the use of bills as a monetary instrument, created especially destructive linkages during the course of the 1763 panic.

3.2 Banking and liquidity

The example in Table 2 suggests that any eighteenth-century merchant could function as a banker, by simply accepting a bill. The historical evidence suggests that in many cases, however, this

[3] Although *C1* still has recourse against *D*, it might be difficult or time-consuming for *C1* to collect. Principal risk could be manifested in other ways as well. Consider a scenario where *B* (for example, Neufville) accepts BILL1 in period 1(a) but goes bankrupt before maturity of the bill in period 2. *C1* has again lost liquidity and *D* is liable for the full amount of the bill. Depending on circumstances, *C1* could lose the entire amount of the initial trade. In a modern context, such cross-border risk might be termed "Herstatt risk" (Committee on Payment and Settlement Systems 2003).

[4] See Davis and Gallman (2001, 127-30); Ferderer (2003, 667-73); and Flandreau and Ugolini (2011, 7).

functionality was unrealized. While virtually all merchants in eighteenth-century Amsterdam dealt in bills of exchange, these dealings were usually quite restricted. Most merchants' bill transactions were limited to a small group of "friends"—commercial contacts in other cities—and even among friends, exposures were subject to strict limits. Also, the typical merchant's bills were rarely transferred more than once after issue (Jong-Keesing 1939, 58-65), indicating that they had limited liquidity. Our analysis of bill settlement patterns suggests that Jong-Keesing's characterization would have been appropriate for over eighty percent of the merchants with accounts at the Bank of Amsterdam, who settled less than one bill per week on average.

The *banquiers* provided a conspicuous exception to this pattern. Surviving records show that the most active merchants in Amsterdam dealt in thousands of bills each year (see Table 3 below), drawn by a wide range of counterparties. When the house of Neufville failed in August 1763, its list of creditors included over 100 bill counterparties, the great majority of these residing in cities outside of the Dutch Republic (Jong-Keesing 1939, 101-110). In many outlying areas, the *only* commonly available form of trade finance was to draw a bill on a banker in Amsterdam.[5] Accepted bankers' bills were widely traded in secondary markets in Amsterdam and other commercial centers.

It is possible to indirectly track much of the bill market in Amsterdam through its settlement activity. Most bills drawn abroad on Amsterdam were payable through a municipally owned institution, the Bank of Amsterdam.[6] [7] At maturity of the bill, the beneficiary (or endorsee) holding an accepted bill brought it to the drawee, who then discharged his obligation by transferring Bank funds to the bill holder in the amount of the face value of the bill.[8] There was no clearing house and no netting of obligations.[9] Meticulous and virtually complete records of the "funds side" of these settlements are preserved in the ledgers of the Bank of Amsterdam: the Bank's

[5] Most markets did have traditional systems of longer-term lending based on mortgages. See e.g. Hoffman, Postel-Vinay and Rosenthal (2000).
[6] The Bank's main purpose was to allow for efficient book-entry settlement of bills of exchange. The Bank's activities generated substantial profits, but it was run more as a public utility than a profit-maximizing entity. See Dillen (1934) and Dehing and Hart (1997) on the history of the Bank.
[7] There was a less important market for "current money" bills—bills settled outside the bank. This market was the domain of a group of intermediaries known as *cashiers*, whose activities are described in section 5 below.
[8] In a modern context, this scheme would be classified as a delivery-versus-payment "model 1" (i.e., gross settlement against the full value of the security; see Committee on Payment and Settlement Systems 1992).
[9] We note that the London Clearing House, the first deposit bank clearinghouse and prototype for many subsequent clearing organizations, was not founded until 1773 (Joslin 1954).

1763 ledgers record around 270,000 transactions (authors' rough estimate)[10] in almost 2,500 accounts.

Competitive pressures kept the number of true "bankers" low. Profit margins on bill acceptance were minuscule, usually 1/3 percent or less (Büsch 1797, 121; Jong-Keesing 1939, 71). In principle, any merchant with a Bank of Amsterdam account could act as a banker; there were no legal barriers to entry or solvency requirements forcing closure. In the absence of ratings agencies or public release of financial information, however, a banker had to maintain a reputation for reliability. Failure to settle a bill could quickly destroy a merchant's reputation, and suspending payments could force a merchant into bankruptcy in matter of days. A critical requirement for bankers was therefore to maintain liquidity, and that meant an adequate balance at the Bank of Amsterdam.

Traditionally, there were two methods to access Bank liquidity. The first was simply to deposit coin into the Bank. "Deposit" is something of a misnomer, as Bank funds had by 1763 taken on many of the characteristics of fiat money (Dillen 1964b, Quinn and Roberds 2010). A deposit functioned essentially like a modern central bank repo transaction: someone depositing high-quality trade coins (*negotiepenningen*) into the bank was credited a certain amount of Bank funds based on official valuations of the coin, and the depositor also received a receipt endowing him with the option to repurchase the same coins within a six-month period at a small cost (¼ percent for most silver coins).[11] A Bank deposit could not be redeemed for coin without a receipt. Analysis of the Bank's vault records indicates that virtually all of these redemption options were exercised, i.e., that in practice "deposits" into the Bank were term repos. The availability of repos effectively pegged the risk-free annualized short-term interest rate at slightly more than ½ percent.

A second way to tap Bank liquidity was to purchase existing Bank funds. This was done in an open outcry market held in front of the Bank every day in which (effectively) coin could be traded against Bank money (Dillen 1964a). The market price was the agio, or gap, between two

[10] Calculated as (6,000 pages) × (90 entries per page) ÷2 (to adjust for double-entry bookkeeping), to yield an estimate of 270,000 transactions.

[11] If a receipt holder chose not to exercise the repurchase option, the initial deposit was treated as a true sale. This feature of the receipt system apparently incorporates the "safe harbor" bankruptcy preference (see e.g., Gorton and Metrick 2010, 276-278) of modern repo contracts, a protection not available to private lenders at the time.

units of account: Bank money (the "bank" guilder or florin) versus the value of circulating money (the "current" guilder or florin). During normal times, arbitrage tended to keep the agio close to official differentials between these two units of account, i.e., between 3.85 and 4.1 percent.[12]

Both of these funding "pipelines" involved the use of expensive, high-quality collateral, i.e., trade coins. The Bank of Amsterdam was a conservatively run institution that did not extend credit against bills, allow accounts to overdraft, or operate any kind of Lombard facility.[13] Despite these restrictions, historical evidence shows that Amsterdam bankers were routinely able to settle bills in amounts that greatly exceeded their average balances at the Bank, without tying up much in the way of high-quality collateral. This trick required the use of creative, ABCP-conduit-like arrangements of the type illustrated in Table 2.

3.2 Evidence

According to our simple model of eighteenth century merchant banking , a banker *B*'s source of market funding would consist of bills drawn on debtors such as *D*. In normal times the banker could easily sell these in the Amsterdam bill market. On the other side, the liabilities of the banker would consist largely of bills drawn on and accepted by *B*, originating with this same group of debtors.

To check the applicability of our simple shadow banking model, we examined the ledger accounts of the Bank of Amsterdam. Notice in the Table 2 example, payments through the Bank's accounts would typically show up at two stages, period 1(c)—the sale of a bill by *B* to *C2*—and, period 2(b)—the settlement of the original bill drawn on *B*. The Bank's ledgers thus provide an incomplete, but still highly informative picture of the banker's activities. In particular, a merchant banker's account at the Bank represents a sort of "virtual conduit" for acceptance loans provided by the banker, recording the payments in by debtors, the payments going out to creditors, and the resultant cash balance.

[12] These boundaries are for the *ryxdaalder* (originally called the *dukaat*), a silver coin that was the primary domestic coin used for repurchase agreements at the Bank (Dillen 1925, 906; Polak 1998, 73-4).
[13] Accounts were not always reconciled on a daily basis, so there were occasional overdrafts. Also, for every year for a century, the Bank of Amsterdam had lent to a government sponsored entity the (Dutch East India Company) to finance ships sailing to Asia (Dillen 1925, 981-3).

An unfortunate limitation of the data is that the Bank's ledgers record no information on the "securities" side of a transaction. This poses several difficulties for our analysis. The first is that information available in modern empirical studies of ABCP (e.g., Covitz, Liang, and Suarez 2009), such as maturity and yield of individual instruments, is lacking.

A second difficulty is that the recorded transfers undoubtedly do, in some cases, represent activity other than bill transactions. For example, Bank accounts were used for transfers of stock, sovereign lending, or sometimes even personal consumption expenditures.[14] However, as the historical literature seems to agree that the principal use of Bank accounts was for bill transactions, we will simply assume that each recorded transaction corresponds to the transfer of a bill.

A third difficulty is that there is no reliable way to sort out banks' cross-exposures. For example, suppose we observe a payment from Bank 1 to Bank 2 on a certain day. This may represent a "type 1" transaction: settlement of a bill previously drawn on Bank 1, but could also represent a "type 2" transaction: Bank 1's purchase, as an investment, of a bill drawn by Bank 2. This distinction does not matter for many of our inferences; however, at the peak of the crisis (August-September 1763) our calculations will assume a lack of discretionary lending (type 2), so virtually all observed transactions are non-discretionary (type 1), for failure to honor an accepted bill had legal consequences such as bankruptcy.

As with modern payment systems, the typical entry in the Bank's ledgers is a datum of the form

$$x_{ijd} \tag{1}$$

representing a transfer of x bank florins from account j to account i on day d, entered as a debit under merchant j's accounts, with a corresponding credit entry for merchant i.[15] Each ledger page also contains an opening balance. These can be combined with the transfer data to yield a daily opening balance b_{jd} for each trading day. The scope of these data, which must be hand tran-

[14] It should be emphasized that transfers over the Bank of Amsterdam's accounts were generally "large-value" payments. The average payment size in the bankers' accounts is about 4,000 florins, as compared to the daily wage for a laborer of approximately one florin (Vries and Woude 1997).

[15] Unlike modern payment systems, the Bank of Amsterdam's accounts do not record the time of day when a payment is made. In fact there is often a divergence of a day between the timing of a debit entry and the corresponding credit entry, suggesting that contemporary concept of "real-time gross settlement" amounted to at best daily settlement of accounts.

scribed, is a challenge. A full accounting of x_{ijd} for the fiscal year 1763 (late January 1763 – early January 1764) as is available with modern systems, would yield a data vector of approximate dimension 1.5 billion (2,455 accounts × 2,455 accounts × ~250 trading days) with approximately 270,000 nonzero entries. To arrive at a dataset of manageable size, a number of simplifications were employed.

The first of these was to time-aggregate x_{ijd} into weekly payment flows for 50 weeks, for the Bank was closed in January and in July to reconcile accounts. We also focus on the eight most active players in the Amsterdam bill market in the years leading up to the panic, as identified in Jong-Keesing (1939, 120). Together, payments to and from these players account for about eight percent of transactions in the Bank's ledgers in 1763, as measured by number of ledger entries. Transactions between these eight accounts and the other account holders are aggregated into the account of a fictional ninth agent ("rest of the Bank" or ROB). Finally, we employ a tenth account to keep track of coin inflows to and outflows from the first nine accounts.[16] The end result of these simplifications is a data vector $\{X_{ijt}\}$ of payments between the ten accounts over weeks $t = 1,\ldots,50$, of a more tractable dimension (≈ 10×10×50 = 5000 data points). In a similar fashion, $\{b_{jd}\}$ was time-sampled to yield a weekly starting balance series $\{B_{jt}\}$.

Table 3 indicates the importance of rollover financing to the banks' activities before the crisis. With one exception (the firm *Andries Pels & Zoonen*), each bank's weekly payments exceed the funds initially available in its Bank of Amsterdam account. While there is some coin deposit and withdrawal activity, the magnitude of this activity is small relative to the banks' payment activity. We also note that the banks as a group are withdrawing more coin than is being deposited, most likely in order to pursue an arbitrage described in Section 7 below.

<Table 3 is displayed in Appendix A>

The data in Table 3 are also consistent with Jong-Keesing's (1939, 74-75) classification of Amsterdam bankers into the established, well-capitalized houses (Hope, Pels, and Clifford) and a

[16] Additional accounts are necessary to track bullion deposits and withdrawals, discrepancies between debits and credits arising from missing entries, and changes in the capital position of the Bank. Details are given in appendix C.

more levered group of "parvenus" such as Neufville (in Table 3, including the firms of Vernede, Smeth, Horneca Hogguer, and Cazenove) who had been able to break into the top ranks of the bankers during the credit boom of the Seven Years' War (1756-1763). The table shows that turnover in the parvenus' accounts is quite active, in two cases (Neufville and Cazenove) exceeding that the established firm of Pels. Bank balances are distinctly lower for the parvenus, and the need for rollover financing correspondingly greater. Viewed from the perspective of its settlement accounts, *Gebroeders de Neufville* does not appear any riskier than similar firms.

The Table 3 data can also be combined with data from Neufville's bankruptcy filing (Jong-Keesing 1939, 121) to shed some light on Neufville's investment strategy. The house of Neufville suspended payments on July 30 with liabilities of 9.6 million bank florins, mostly in bills, and (book) capital of 413 thousand florins, implying a leverage of 24 times capital. Neufville's weekly settlements through the Bank amounted to about 239,000 florins, implying that at least 2.5 percent of the firm's portfolio was rolled over during an average week.[17]

An alternative perspective on liquidity flows documented in Table 3 is offered by the methodology developed in Bech, Chapman, and Garratt (2010) [BCG]. Following their analysis, we fit a simple Markov chain with states $\{1, \ldots, 9\}$ to the payments data X_{ijt}, where the states correspond to the eight large banks plus the ROB proxy account for the remaining Bank of Amsterdam account holders. An "adjacency matrix" is constructed for each data week *t*

$$W_{ijt} = \frac{X_{ijt}}{\sum_j X_{ijt}}. \tag{2}$$

The matrix W_t is a stochastic matrix that indicates the probability of a guilder moving from one Bank account to another. Following BCG, adjusted transition matrices A_t for the Markov chain are then constructed from W_t, by taking

$$a_{iit} = \theta_i \in [0,1] \tag{3}$$

and

[17] Neufville would have also needed to settle some bills payable in current money (Jong-Keesing 1939, 93).

$$a_{ijt} = (1 - \theta_i) w_{ijt} \tag{4}$$

for $j \neq i$. BCG interpret the parameters θ_i as the tendency of liquidity to be retained in account *i*. Note also that from each A_t one can calculate an associated steady-state probability distribution π_t over states, using standard techniques.

To calibrate the BCG model for January-June 1763, we first calculated the sample mean of the distribution of relative starting balances ("liquidity") $y_{it} = B_{it} / \left(\sum_i B_{it} \right)$ over the nine accounts. We then chose θ_i to match this mean vector, by calculating time series of transition matrices A_t and the sample mean of the corresponding time series of implied steady-state distributions π_t.[18] A three-parameter specification fits the empirical liquidity distribution very closely (see Appendix *B*). Under this specification, $\theta_i = 0$ for the parvenus (normalized value), $\theta_i = .54$ for the established banks, and $\theta_i = .96$ for the rest of the bank. In words, liquidity is returned instantaneously from the parvenus, at an intermediate pace from the established banks, and very slowly from the remaining accounts.

4. Collateral shocks

The Seven Years' War led to a sharp expansion in lending activity in Amsterdam. The Amsterdam bill market financed a wide range of activities associated with the war, including the movement of military supplies, the floatation of sovereign loans, and movements of specie designed to take advantage of fluctuating exchange rates (Jong-Keesing 1939, 55-86, Henderson 1962, 94-95). The countdown to the August 1763 panic began with the slowdown of hostilities in late 1762. The Treaty of Hubertusburg (February, 1763) concluded the war and spawned two shocks that diminished the value of the collateral backing Amsterdam's bill transactions.

The first shock was a drop in the price of perishable commodities. Stocks of grain which had been essential to maintaining armies in the field suddenly lost value. Grain prices in Berlin and

[18] Formal estimation is problematic since (1) as BCG note, their model is not identified if all components of θ are free, and (2) in our relatively sparse dataset there is little time variation in the sample distribution of liquidity.

Hamburg dropped by 30 percent between November 1762 and May 1763. Even more ominous was the decision by Prussia to dump its unused grain supplies on the Berlin market in May 1763, leading to a 75% drop in the local price of wheat, with other agricultural prices soon following (Schnabel and Shin 2004, 956-959). These sudden price movements impacted many of the Amsterdam traders' counterparties in Berlin, but also some of the Amsterdam traders themselves. Neufville, in particular, had collaborated with a "friend," prominent Berlin merchant Johann Ernst Gotzkowsky, in a disastrous deal to purchase a million guilders' worth of grain from the departing Russian army at the war's end (Skalweit 1937, 94-95).

The second shock resulted from a sudden change in the direction of Prussian monetary policy. At the start of the war, Prussia was on a monetary standard (i.e., mint equivalent) of 14 Reichsthalers per mark of fine silver. As the war persisted and Prussia's fiscal situation became more desperate, a sequence of debasements eventually raised mint equivalents to as high as 40 thalers per mark for some coins (Koser 1900, 341-351). The wartime inflation was extremely unpopular with the nobility, and in May 1763 Prussia issued a new mint ordinance with the intent of reversing its inflationary policies. The new ordinance demonetized the depreciated war coinage and reduced the mint equivalent of the Reichsthaler to a "transitional" level of 19.75 thalers per mark (Henderson 1962, 96).[19] Again Neufville was negatively impacted. The firm had anticipated receiving a contract from the Prussian crown to deliver silver for the new coinage, but this deal did not materialize (Spooner 2002, 82).

Prussian merchants holding debased wartime coinage now saw the nominal value of their collateral cut in half. They responded by sending the demonetized coins to other markets where they might have higher value as bullion (Büsch 1797, 123; Skalweit 1937, 45). Much coin was shipped to Hamburg, where it was melted and converted to deposits at the Bank of Hamburg. The Hamburg institution was a close copy of the Bank of Amsterdam, but unlike the Amsterdam institution, it traditionally allowed depositors to pledge bullion as collateral (Sieveking 1934). After undergoing this "liquidity transformation," the silver could be accessed via bills of exchange payable at the Bank of Hamburg. Concerned about the inflow of unminted silver and the

[19] This decision to undertake this move had already been made in December 1762, and word may have leaked out, as the Reichsthaler appreciated by about 10 percent from November 1762 through April 1763 in both Amsterdam and Hamburg (Schnabel and Shin 2004, 958).

subsequent outflow of high-quality coins, the Bank of Hamburg stopped accepting bullion deposits, apparently sometime in early 1763.

The closing of the Hamburg bullion window led Hamburg merchants to ship silver directly to Amsterdam (Büsch 1797, 124). Silver bullion was not eligible for deposit at the Bank of Amsterdam, but could be pledged as collateral in private transactions. However, the Amsterdam market seems to have become quickly flooded with this type of collateral. Jong-Keesing (1939, 88, note 4) cites a May 31 letter by the Amsterdam merchant De Vogel to his Hamburg correspondent Emanuel Jenisch, describing the state of the Amsterdam money market at that time:

> It is to our regret that the circumstances of business are now such that we cannot make our correspondence profitable … money is extremely scarce and the discount of first-rate bills is running at 5 percent[20] in Bank money … . The crude bars of silver that are being smelted here from the money arriving in great quantities from Germany, cannot be sold and are everywhere being borrowed against; these are also being discounted by 7 percent. … Everything is bad for business.

5. Outbreak of the panic

The proximate cause of the failure of Neufville was the suspension of payments by the minor firm of *Aron Joseph en Compagnie* on July 28, 1763 (Jong-Keesing 1939, 121). Neufville's exposure to Aron Joseph was 163,000 florins, small relative to Neufville's total book of 10 million florins, but meaningful in the context of its 241,000 florin weekly funding requirement (Table 3). Neufville suspended its payments at the Bank on July 30.

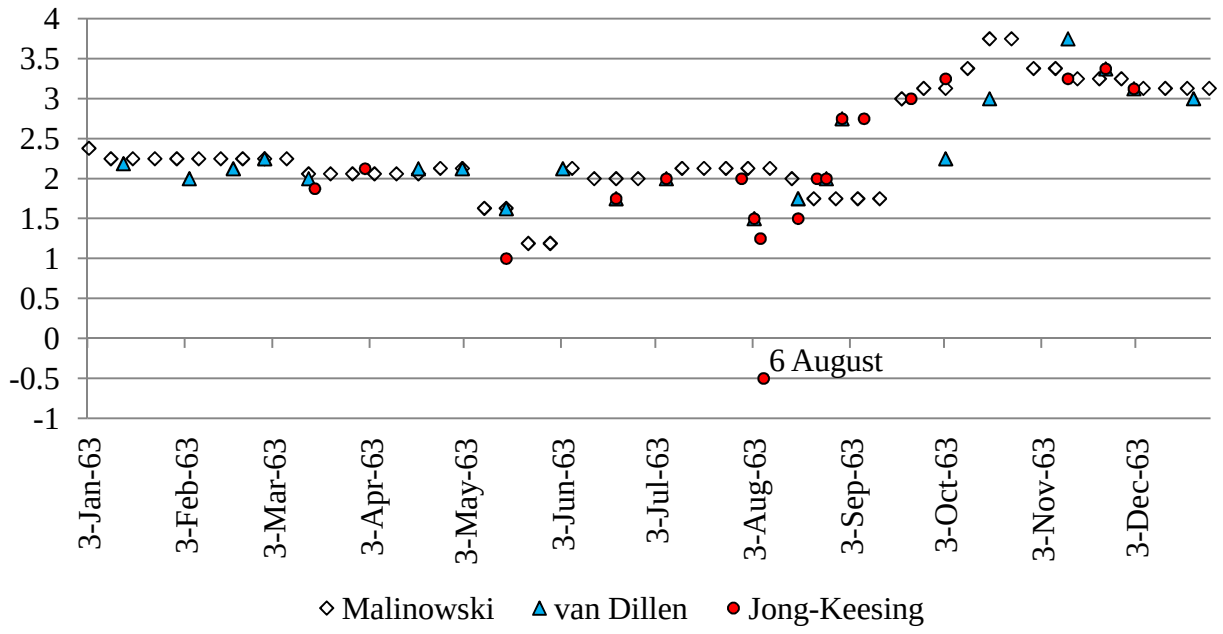
The failure of a firm of Neufville's size—almost half as large as the Bank of Amsterdam itself—shocked the Amsterdam markets. The immediate victims were a group of firms known as *cashiers*. The cashiers were comprised of about thirty financial intermediaries whose activities formed a bridge between the large banks and ordinary merchants. Traditionally the cashiers had served as brokers in the market for Bank funds (Dillen 1964a). By the last half of the eighteenth century, their activities had expanded to include settlement of bills denominated in current guilders, deposit-taking, and even the issue of "cashier's receipts" that circulated locally as banknotes (Jong-Keesing 1939, 80-81). The cashiers were run hard during the first days of the crisis, as pa-

[20] Two to three percent was normal (Schnabel and Shin 2004, 942).

nicked holders of cashier's receipts demanded coin from the issuers (Jong-Keesing 1939, 94-95, 164-165).

The runs on the cashiers had only an indirect effect on the Bank of Amsterdam, as the Bank itself was unlikely to be subject to runs.[21] To withdraw coin from the Bank, one had to have a deposit receipt. Such claims were viewed as extremely secure, and receipt holders saw little reason to sell their redemption options at a time of financial unrest. Account holders without receipts could no more run the Bank than a modern holder of fiat money can run a modern central bank. What they could do was to bid down the price of Bank money, denominated in bank guilders, against coin, denominated in current guilders, in the open market. Figure 2 shows in the days immediately following Neufville's failure, the market agio on Bank money fell from 2 percent[22] to 1 percent. On Saturday, August 6, the market agio fell below zero, to a discount of ½ percent.

Figure 2. Select daily agio observations in 1763, in percent



Sources: Malinowski (2011), van Dillen (1931, 34); Jong-Keesing (1939, 165).

[21] However, it is likely that the Bank did feel pressured, as evidenced by its not making any new loans to the East India Company after August 1763, and the Bank made no loans to the company in 1764.
[22] The end of the Seven Years War encouraged many to repatriate money from Amsterdam, so the agio was already low (below 3.85) during the first half of 1763.

After two days and a central bank intervention (see Section 7 below), the agio bounced back up to 2.13 percent, but the emergence of a negative agio was stunning development, comparable to the appearance of negative T-bill rates the wake of the Lehman failure (Derby and Rappaport 2008). A negative agio had been observed only once before, during the French invasion of 1672 (Quinn and Roberds 2010, 16).

We interpret this development not as a sign of weakness of the Bank, but as evidence for an extraordinary demand for coins, and a breakdown in the normal pricing relationships between current and bank guilders. Bank funds were still in high demand, to settle accepted bills of exchange that were now coming due. In a normal market, a negative agio would have been immediately arbitraged away by traders withdrawing coin from the bank, selling the coin for bank funds in the open market, and using the bank funds to purchase more coin. Such arbitrages were unattractive in a dysfunctional market, however.

6. Loss of liquidity in the Amsterdam bill market

In contrast to the cashiers, the first-round effects of Neufville's failure on the shadow banks appear to have been rather limited. Rumors had been circulating for some time concerning Neufville's solvency, and most of the large firms appear to have limited their exposure accordingly.[23]

More devastating to the large banks were the second-round effects of the crisis. In Amsterdam's most important satellite market, Hamburg, claims against Neufville amounted to around three million florins, spread over 38 counterparties (Jong-Keesing 1939, 102). The bill market there was faced with virtual collapse. On August 4, a group of prominent Hamburg merchants sent a petition to Amsterdam, demanding a bankruptcy preference, and threatening a shutdown of their market for Amsterdam bills if this was not granted:[24]

> This morning … we received a fatal express, with the terrible news that you, the gentlemen of Amsterdam, would leave the Neufvilles to sink, by which we were all thun-

[23] The exception was Smeth, whose bankruptcy claim against Neufville amounted to 318,750 bank florins (Jong-Keesing 1939, 110), twice its average weekly funding need (Table 3).
[24] See Soetbeer (1855, 51) and Sautijn Kluit (1865, 25-26); English translation is from Tooke (1838, 149-150).

> derstruck; never dreaming that so many men in their senses in your city could take such a step … which will infallibly plunge all Europe in an abyss of distress, if not remedied by you whilst it is still time.
>
> We therefore send this … general letter to you …, to exhort and conjure you … to undertake still to support the Neufvilles, by furnishing what money they want, and giving them two or three persons of unquestionable probity and skill, for curators, that their affairs and their engagements may be concluded and terminated, without causing a general ruin … .
>
> If you do not, gentlemen, we have unanimously resolved to suspend our own payments as long as we shall judge it proper and necessary; and that we will not acquit them, or the counterprotests that shall come from you, or any whatever.

This proposal was rejected after some debate,[25] and the Hamburg merchants' threat only served to initiate a three-month long shutdown of the Amsterdam market for Hamburg bills. To preserve their own liquidity, Amsterdam bankers protested virtually all incoming bills drawn by Hamburg counterparties (Jong-Keesing 1939, 166-171). In Hamburg, this blockade of acceptance credit forced 93 firms into bankruptcy during the month of August (Soetbeer 1855, 52; Schnabel and Shin 2004, 943-944). Similar shutoffs of credit and clusters of failures occurred in other places dependent on the Amsterdam bill market, including Berlin (Skalweit 1937, 50) and Stockholm (Jong-Keesing, 193-198).[26]

6.1 Measuring the loss of liquidity

The contraction of the bill market put the Amsterdam merchant bankers under heavy pressure, as their ability to roll over funding (draw bills on debtors) was severely constricted. Although the bankers did not issue deposits and could therefore not be "run" in the classical sense, they faced a broadly equivalent loss of "funding liquidity" (Brunnermeier 2009, 91). The bankers did attempt to control their exposures by protesting incoming bills. At the same time, they were subject to an immovable requirement to settle accepted bills: since the maturity ("usance") of bills

[25] A private bailout fund ("super SIV") of 700,000 guilders was considered and rejected, largely due to the unpopularity of the Neufvilles (Jong-Keesing 1939, 121; Spooner 2002, 83.)

[26] From the viewpoint of the Amsterdam banks, the blanket protests of foreign bills were justifiable as a way to insulate themselves from potential insolvencies of Neufville's counterparties. To the merchants in the outlying markets, these protests seemed like nothing more than a liquidity grab; a common complaint was that Amsterdam bankers even protested bills that were covered by collateral and therefore posed no credit risk to the drawee (Skalweit 1937, 86). Our data do not allow us to distinguish between these views.

drawn on Amsterdam was six weeks to two months (Schneider et al. 1991, 66-101), each bank would have begun the panic with an outstanding stock of settlement obligations.

Surviving records indicate either no bill trade or sparse quotations for Amsterdam bills drawn on virtually all locations, over July-October 1763.[27] When bills could be sold they went at depressed prices, even if they were drawn on places unaffected by the Neufville failure (Jong-Keesing 1939, 167).[28] For example, consider London, Amsterdam's most integrated international exchange partner (Neal 1990). Average exchange rates in Amsterdam weaken (Table 4), but the full cost of initiating acceptance finance depended on the rate that the London counterparty used to return the principal obligation to Amsterdam. Table 4 gives the hypothetical round trip cost[29] of a four month loan (2 months out, 2 months back) using (1) a naïve *ex ante* assumption that the latest London rate available in Amsterdam would pertain at "re-exchange"[30] and (2) using an *ex post* assumption of the actual London rate two months later. Expected borrowing costs rose to over 10 percent, and realized rates were higher still as London adjusted to the liquidity crisis in Amsterdam. Privately supplied liquidity, when it was available, became extremely expensive.

[27] Including bills drawn on Breslau, Danzig, Hamburg, Lisbon, Livorno, London, Paris, and Vienna. See Jong-Keesing (1939, 168-171) and Schneider et al. (1991, 66-101).
[28] A similar situation occurred in late 2007 when many ABCP conduits were indiscriminately run (Covitz et al. 2009).
[29] Under the assumption that a lender of funds viewed as credible the sequence of actions in Table 2.
[30] I.e., the drawing of a bill by the London drawee on the original (Amsterdam) drawer (i.e., borrower).

Table 4. Average exchange rates for Amsterdam on London

	Schellingen Banco/ English Pound, 2 Month Bills	*Ex Ante* Re-exchange Rate, Annualized	*Ex Post* Re-exchange Rate, Annualized
January 1763 Through July	34.50	4.2%	4.2%
August	34.26	6.6%	12.3%
September	33.79	10.9%	19.7%
October	34.65	6.6%	11.9%
November	34.82	8.7%	10.3%
December	35.13	7.4%	11.6%
January 1764	35.79	1.9%	6.7%
February	35.88	4.8%	4.4%
March	36.02	4.7%	4.1%

Sources: Amsterdam rates from Jong-Keesing 1939, 168; London rates from the *Course of the Exchange*.

Loss of liquidity can also be seen in the payments data. One measure of market density is given by a metric similar to that used by McAndrews and Rajan (2000) to study intraday payment flows over Fedwire. This is the percentage of interbank payments funded through incoming transfers

$$PIT_t \equiv 100\left(1 - NR_t\right) \ , \tag{5}$$

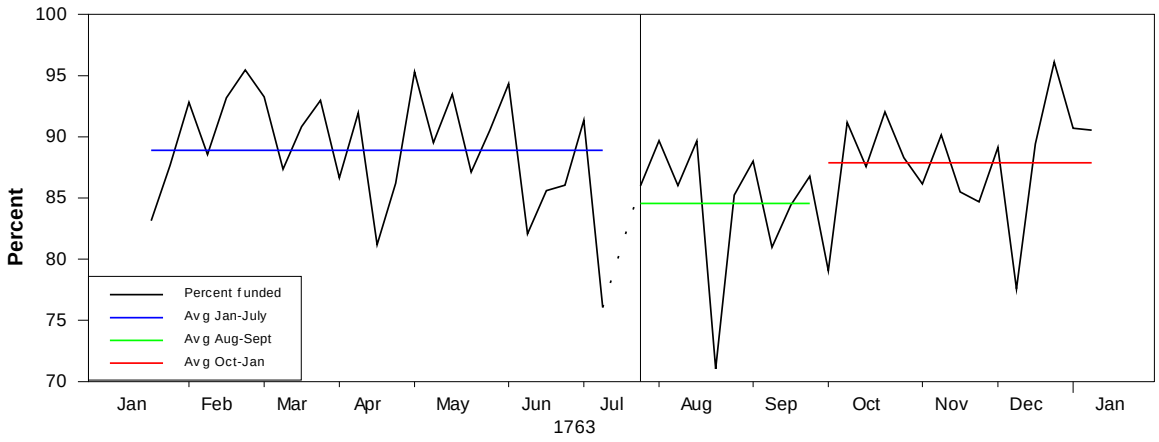
where NR_t is the ratio of net to gross "interbank"[31] payments observed during week *t*, calculated as

$$NR_t \equiv 0.5\left(\sum_{i=1}^{9}\left|\sum_{j=1}^{9} X_{ijt} - \sum_{j=1}^{9} X_{jit}\right|\right) / \left(\sum_{i=1}^{9}\sum_{j=1}^{9} X_{ijt}\right) \tag{6}$$

The higher the value of PIT_t the more symmetric are the flows of liquidity, and the less need for banks to fund their settlement positions by providing additional collateral. Figure 3 charts the evolution of PIT_t over the data sample.

[31] "Interbank" transactions are defined as transactions between two private accounts, i.e., ledger entries that do not involve the movement of metal into or out of the Bank.

Figure 3: Percentage interbank payments funded by incoming transfers, 1763:1-1764:1



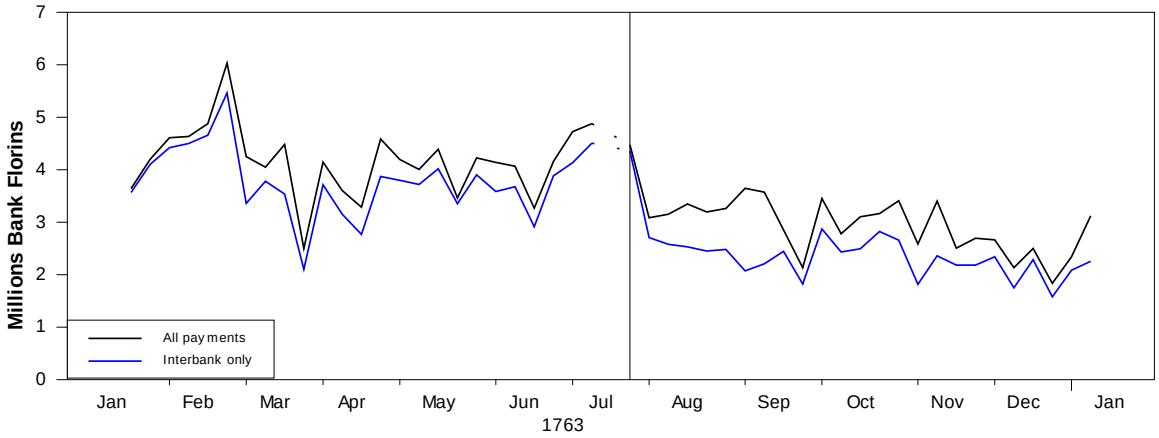
Source: Stadsarchief Amsterdam 5077.

The mean weekly percentage of payments funded through incoming transfers is about 89 percent before the Neufville failure, but drops to 85 percent over the two months following the outbreak of the crisis, indicating a greater need to fund positions through the posting of collateral.[32] In the last four months of the sample, there is a recovery to 88 percent.

Our final method of measuring changes in liquidity pre- and post-crisis is to simply calculate the total value of payments made through the ten accounts we track, i.e., $TV_t \equiv \sum_{i=1}^{10}\sum_{j=1}^{10} X_{ijt}$, which is done in Figure 4. The figure also displays a second series incorporating only the value of interbank payments $TIV_t \equiv \sum_{i=1}^{9}\sum_{j=1}^{9} X_{ijt}$. Mean weekly payments value declines from 4.17 million florins (pre-Neufville failure) to 2.97 million florins (post-Neufville), a drop of over 25 percent. Interbank payments contract even more sharply, by almost 37 percent.

[32] It is interesting to contrast these figures with comparable numbers for other payment systems. Data for payments made through the New York Clearing House over the period 1854-1908 imply a daily PIT of about 95 percent (Cannon 1910, 221). For modern large-value payment systems, daily figures of over 99 percent are common (Bech and Hobijn 2007). We conjecture that the relatively high liquidity demand of the banks in our sample can be attributed to (1) the comparatively sparse flow of payments, (2) incompleteness of the data sample, and (3) the absence of tiering (settlement through third parties), as compared to later systems dominated by deposit banks.

Figure 5: Aggregate payments value (weekly), 1763:1-1764:1



Source: Stadsarchief Amsterdam 5077.

To gain some perspective on these numbers, it is instructive to consider changes experienced in analogous aggregates in the wake of the Lehman bankruptcy. The daily mean value of U.S. dollar payments over large-value systems[33] falls from $8.6 trillion in 2008 to $7.0 trillion in 2009, a reduction of 18 percent. (Committee on Payment and Settlement Systems 2011, table PS-3). Higher frequency (monthly) statistics are available only for the Fedwire system[34], and these show a different pattern from that displayed in Figure 4. Fedwire payments activity peaks around the time of the Lehman failure (reaching an all-time high of $3.2 trillion/day in September 2008) and declines only gradually thereafter. Thus, Figure 4 attests to a substantial and immediate contraction of the Amsterdam bill market in August 1763.

7. Policy response

The post-Neufville credit freeze-up ultimately forced 38 Amsterdam firms into bankruptcy during August and September 1763 (Jong-Keesing 1939, 130-145). Compared to Neufville, howev-

[33] Computed as sum of the annual value of payments over Fedwire, the value of payments over CHIPS, and 85 percent of the value of payments over the multicurrency CLS system, all divided by 250.
[34] www.frbservices.org/operations/fedwire/fedwire_funds_services_statistics.html.

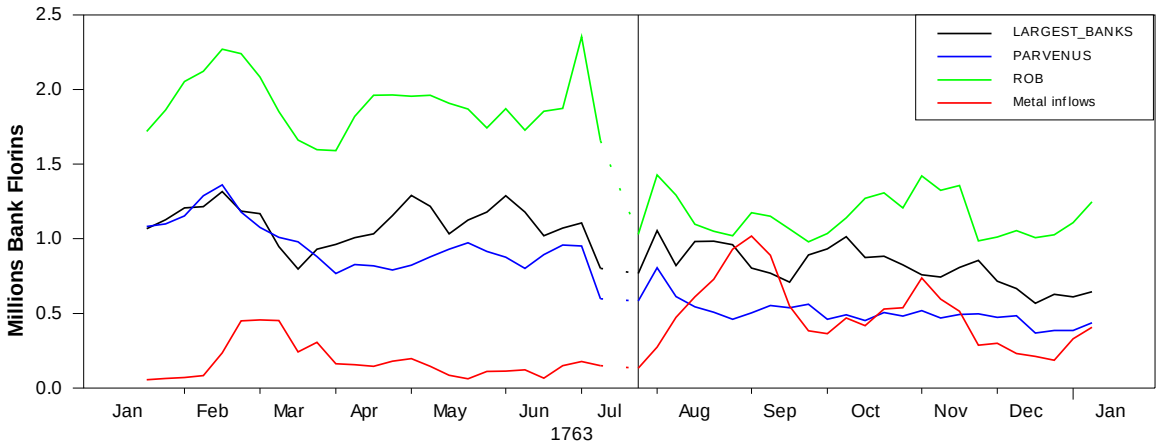
er, these were small enterprises,[35] and many were able to reopen within a few months, after settling with creditors.[36] By October, there are signs of the market returning to a more "normal" state, albeit at lower levels of activity than before (Figure 4). These include a return of the agio to a more normal range (Figure 2), an increase in the percentage of payments funded through incoming transfers (Figure 3) and a recovery of the exchange rate (Table 4). The Amsterdam market as a whole was able to escape the devastation that took place in outlying locations.

This section will argue that a major reason for the comparatively mild impact of the panic in Amsterdam was the provision of liquidity through the Bank of Amsterdam, which was able to compensate for a shortage of market liquidity. As hinted at in Figure 1, demand for Bank balances was accommodated through two mechanisms. The first was the traditional "repo" (i.e., receipt) window for trade coins. The second was a new facility, a receipt window for unminted silver bullion. The bullion window was authorized on August 4, and the first transaction using this window was recorded on August 6, the day the agio turned negative.[37]

Figure 5 gives some indication of the impact of these two facilities. The figure decomposes the transactions in Figure 4 into groups, according to source of origination. The groups are (1) interbank transactions originating from the three large established banks; (2) interbank transactions originating with the parvenus; (3) interbank transactions originating from other Bank account holders (ROB); and (4) inflows of metal, in the form of either coin or bullion.

[35] The next largest bankrupt after Neufville was Cornelis Karsseboom, with liabilities of 3.5 million guilders (Jong-Keesing 1939, 146). The average liabilities of a bankrupt amounted to 669,000 guilders (Schnabel and Shin 2004, 963).
[36] Settlements were common, given that "normal" resolution of bankruptcy could last up to 33 years.
[37] For authorization, see Dillen (1925, 412). For start, see Amsterdam Stadsarchief 5077/1390, p. 30.

Figure 5: Payments value by source, 1763:1-1764:1



3-week moving averages. Source: Stadsarchief Amsterdam 5077.

The figure shows that all interbank payments contract following the Neufville failure. The contraction is strongest in the ROB proxy account, from a pre-crisis level of about 2 million guilders/ week (cf. Table 3) to a lower level of about 1.2 million, reflecting a lower demand for bankers' bills. Payments originating in bankers' accounts do not drop off as quickly, Neufville's collapse notwithstanding. Lack of market funding caused the bankers to have a shortfall of about 300,000 guilders per week, which was partly made up through metal deposits. Metal inflows peak about six weeks into the crisis, a time frame roughly corresponding to the usance of bills drawn on Amsterdam in places such as Hamburg or Berlin.

The next sections provide a more detailed analysis of the impact of metal inflows.

7.1 Coin window

In many respects, coin deposits at the Bank of Amsterdam functioned much as modern central bank repurchase transactions. Differently from the usual practice of modern central banks, however, the Bank did not try to actively vary the terms of its coin window. Nor did it attempt to manage the quantity of receipts outstanding, but simply allowed these to adjust to market condi-

tions.[38] Thus, much of post-Neufville adjustment in the money stock can be attributed to endogenous shifts in the use of this facility, reflecting changes in market strategies of the merchant banks.

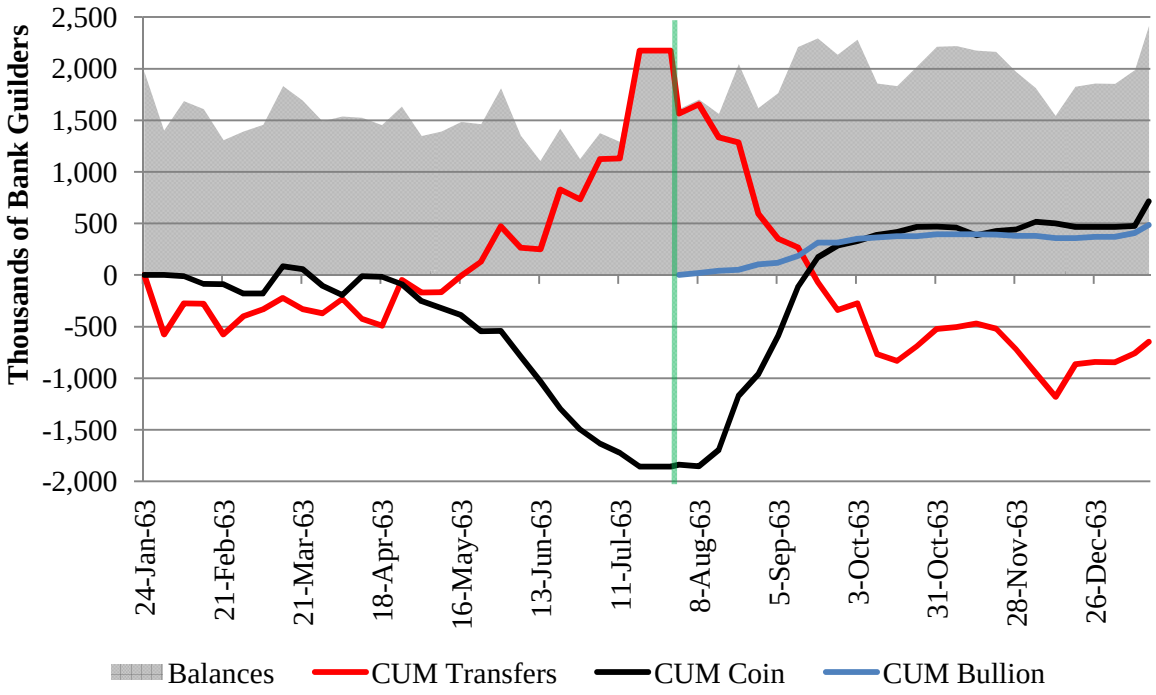
Before the outbreak of the crisis, the data suggest that the merchant banks had been engaging in arbitrage. The Bank of Amsterdam's coin window allowed for redemptions of deposits (with a receipt) at fixed terms that created an implied agio of around 4 percent depending on the coin. Hence, when the market agio was below this official agio, someone holding a receipt option could effectively purchase coins from the bank using the receipt contract's relatively high implied agio. They could then use the coins to purchase bank guilders at the low market rate (around 2 percent depending on the week; see Figure 2). The process, however, had an endogenous regulator in that the receipts themselves were negotiable with their own market price. The execution of repurchase options would push up the price of remaining options and so increasingly capture arbitrage profits without having to execute the repurchase.

Evidence of such arbitrage activity is given in Figure 6, which shows how the eight bankers (as a group) kept their collective weekly balances (the grey area) stable. Before the failure of Neufville (vertical green line), the cumulative change (from the year start) in balances from net coin repos (black line) remains negative, while the cumulative change in balances acquired by transfer from the rest of the bank (red line) is positive by a similar amount. By mid-summer, this process had churned through about 2 million bank guilders.

<Figure 6 follows next page>

[38] In a similar vein, the European Central Bank engaged in several fixed-rate open market operations of indefinite size ("fixed rate tenders with full allotment") in order to meet post-Lehman demands for liquidity; see Catalão-Lopes (2010).

Figure 6: Weekly total banker balances in 1763 with accumulation by channel

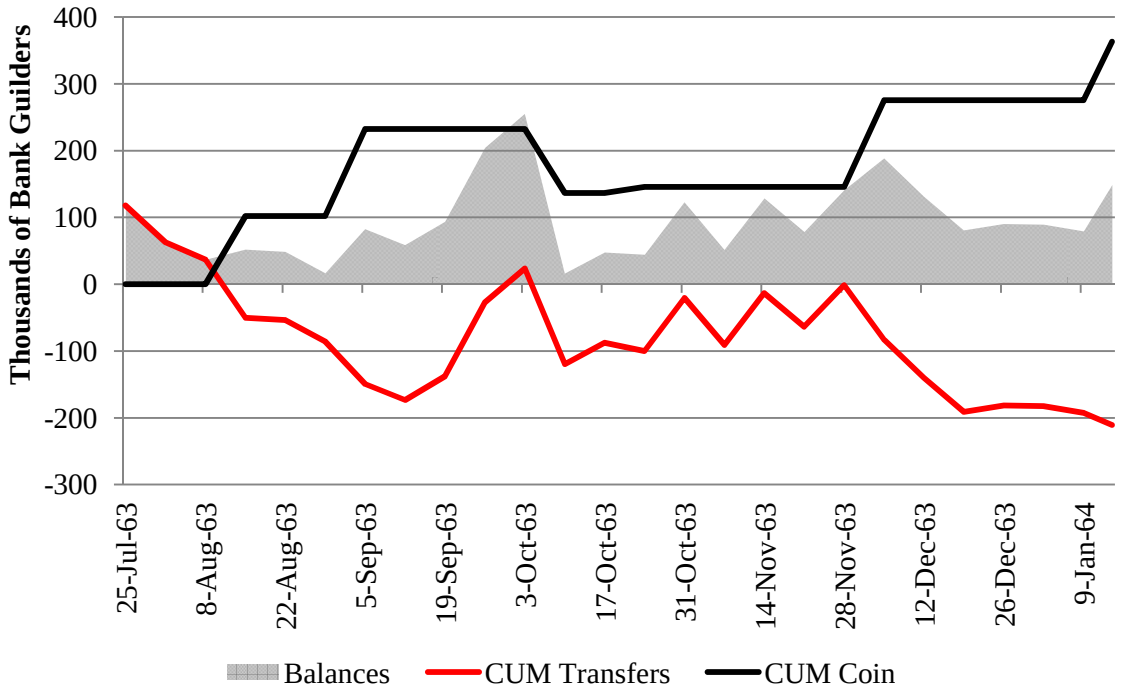


Source: Stadsarchief Amsterdam 5077.

Following the Neufville failure, net transfers flowed relentlessly from the bankers for two months. To maintain their overall balances, the bankers created 2 million new bank guilders by bringing coin collateral into the bank. That is, the bankers forsook arbitrage returns and instead chose an expensive channel to maintain their balances. This channel generated large amounts of liquidity without the Bank taking any new policy action.

More specific evidence on the use of the coin window is given in Figure 7. The figure displays the weekly balances of a particular merchant bank, *Horneca Hogguer en Compagnie*, from July 29, the day before the Neufville failure, to the end of the Bank's fiscal year. Horneca Hogguer's cumulative position from net transfers declines rapidly in August, and its account would have already become illiquid the week of August 8 but for coin receipts. Horneca Hogguer did not make use of the bullion window, but was able to maintain its liquidity position through the deposit of coin.

Figure 7. Weekly balances of Horneca Hogguer



Source: Stadsarchief Amsterdam 5077.

7.2 Bullion window-design

The policy dilemma facing the facing the Bank of Amsterdam in August 1763 is easily recognized from the recent crisis: an extraordinary demand for central bank balances, combined with a surfeit of collateral, only most of it (silver bullion in particular) not eligible for transactions with the central bank. Somewhat differently from 2008, it was possible for market participants to convert ineligible collateral (bullion) to eligible collateral (trade coins) by taking the former to a mint.[39] Many people did take bullion to the mints, but production was slowed by technological and labor issues (Jong-Keesing 1939, 50).

The improvised solution was for the Bank to expand its repo window to include unminted bullion. In designing this program, a key political constraint was that the Bank not undercut the business of the mints, a major source of governmental revenue. Accordingly, the new window had to deliver fewer bank guilders than turning bullion into a new coin. The Bank satisfied this

[39] Mints functioned essentially as private operations subject to government regulation (Jong-Keesing 1939, 51).

constraint by fixing the bullion "bank price" at 22.91 bank guilders per mark pure silver.[40] In 1763, most large silver coins produced by the Dutch Republic had a mint price of 25.1 current guilders per mark (Polak 1998), so minting bullion and then selling the resulting coin at the market agio (denoted as *a*, a percent premium) would produce the same bank guilders as the bullion window as long as

$$25.1 \times \left(\frac{1}{1+a} \right) = 22.91, \text{or } a = .0956 . \tag{7}$$

Hence, the bullion window would not improve on the minting and the subsequent selling of new coins unless the agio was above 9 ½ percent: not a worry in 1763. Alternatively, people could bring new coins to the Bank. For that purpose, the most attractive coin was the *ryxdaalder*, for it had a combined mint-and-receipt value of 24.1[41] bank guilders per mark, and that value was distinctly more attractive than the 22.91 offered by the window.

Yet the new window still appealed to people who needed bank guilders immediately or did not want to risk tying up their collateral at the mint. There already existed two ways to rapidly convert bullion into bank guilders: use the bullion as collateral for a private loan or sell the bullion on the open market. The new window improved on the collateral approach. The bank charged a 1.0025 percent annualized rate (6 months at a ½ percent). Three months before the panic, lenders were charging as much as 7 percent (we assume annually) for loans against bullion.[42] The short-term rates during the crisis were higher still (see Table 4), if a lender could be found at all. Hence, the Bank's window offered guaranteed access to loans at an attractive rate.[43]

The penalty for use of the window was given by an implicit "haircut," for the market price of bullion was well above the 22.91 offered by the Bank. To calculated the value of the haircut, we first note that the market value of bullion in bank guilders was the price of a mark of pure silver

[40] For bullion of 11/12ths fineness or better, the price was 21 bank guilders per mark (Dillen 1925, 412). Less fine bullion was credited at fewer bank guilders per pure mark.
[41] 24.1 = (25.1 current guilders per mark fine silver)*(2.4 bank guilders per coin/2.5 current guilders per coin).
[42] See the discussion on p. 18 above.
[43] This may have been possible only because by tradition, the Bank enjoyed much the same creditor protection as a modern repo lender. By contrast, private creditors who lent to Neufville against bullion collateral were fully compensated, but only after several months' lag (Jong-Keesing 1939, 124).

in current guilders θ, converted using the agio a. The value of silver at the new window equals the market if

$$\theta\left(\frac{1}{1+a}\right) = 22.91\,. \tag{8}$$

However, no source records a value of θ below 25 current florins (Jong-Keesing 1939, 92; Nogues-Marco 2011, 44), for the mint price of 25.1 created a price floor. Thus, equation (8) implies that at a market agio of 2 percent, and an implied market silver price of 24.5 bank guilders per mark, the bullion window's haircut was around 6 percent.[44] This meant that 1) the window was less accommodating than first appears, 2) borrowers had a strong incentive to execute the repurchase (endogenously unwind) when conditions calmed and 3) the window did not disrupt the normal sale of bullion. It did, however, provide a backstop to the bullion market.

7.3 Bullion window-usage

While much smaller in scale than coin receipts (see Figures 1 and 6), we find that the bullion window made a critical difference for some players. Figures 8 and 9 report the evolution of balances for the firms Cazenove and Smeth, respectively. The figures also show the cumulative positions by net transfers (red), by net coin receipts (black), and by net bullion receipts (blue).[45] Cazenove would have become illiquid the week of August 8 without coin receipts and would have become illiquid the week of August 20 without bullion receipts. Smeth evidently needed both facilities to retain positive balances after week of September 19.

Thus, under the defensible assumptions that Cazenove's and Smeth's transactions are predetermined over the months of August and September (due to usance conventions), and that their use of the bullion window demonstrated that they had little or no coin left to serve as collateral (due to the Bank's haircut), it is reasonable to conclude that use of the bullion window prevented the failure of two more "parvenu" banks—market players of approximately the same size and leverage as Neufville (Table 3).

[44] Private creditors may have haircut such collateral even more aggressively (Jong-Keesing 1939, 93).
[45] Bullion includes funds dispersed through an ad hoc account created from barrel (*vaaten*) silver. See Appendix C for details.

Figure 8. Weekly balances of Cazenove

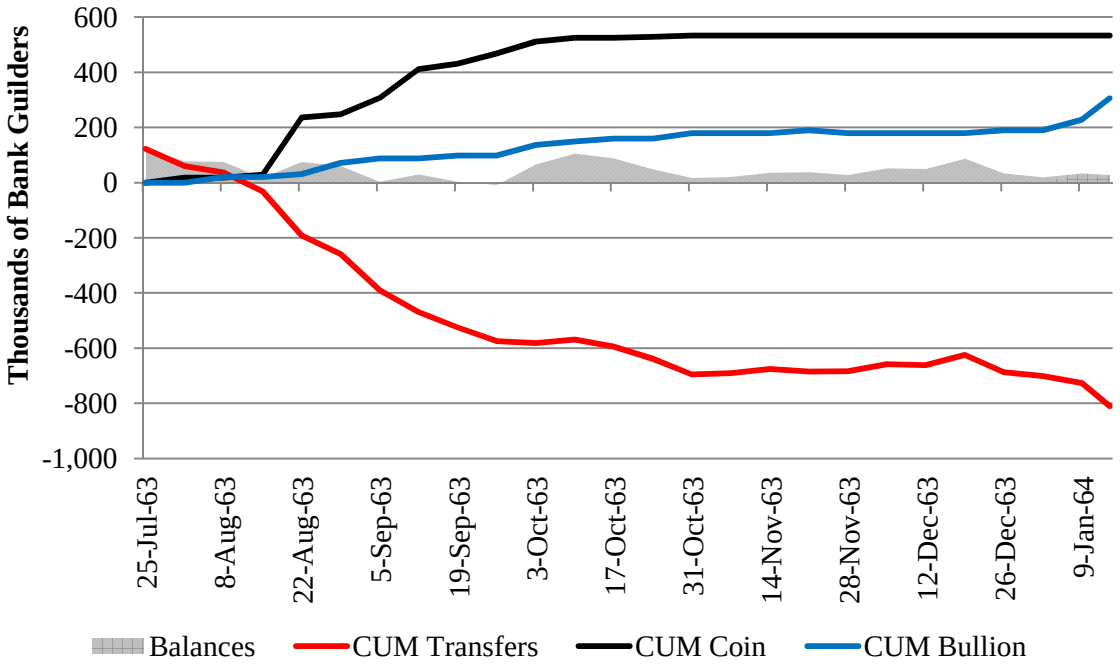
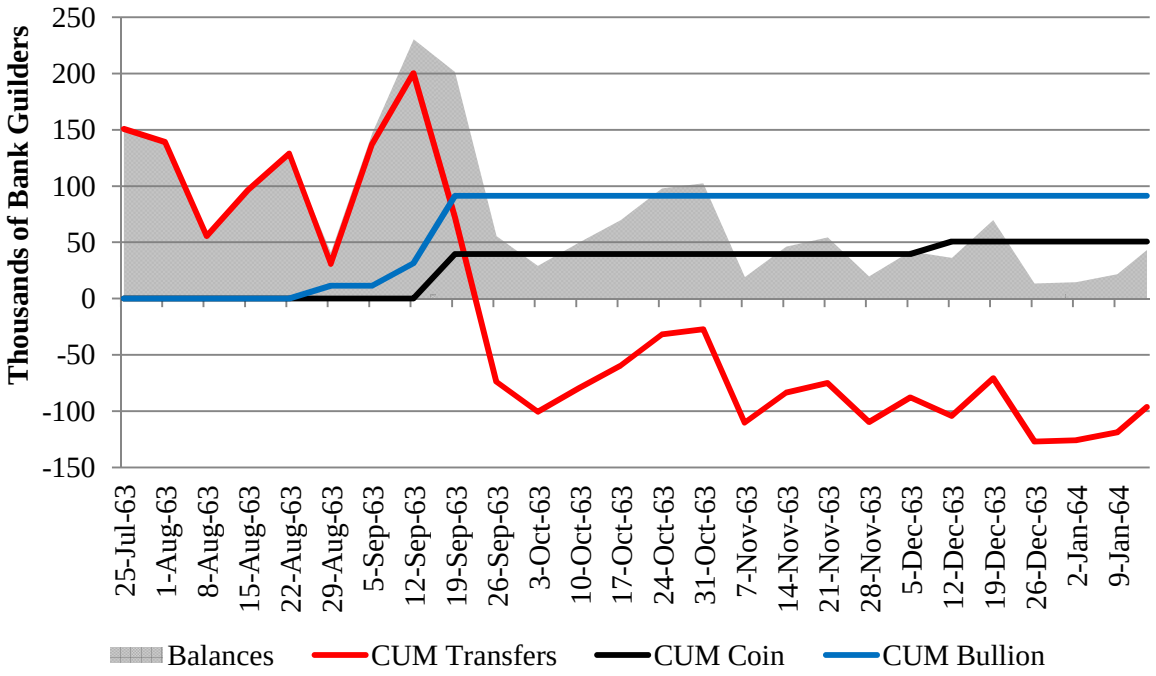


Figure 9. Weekly balances of Smeth

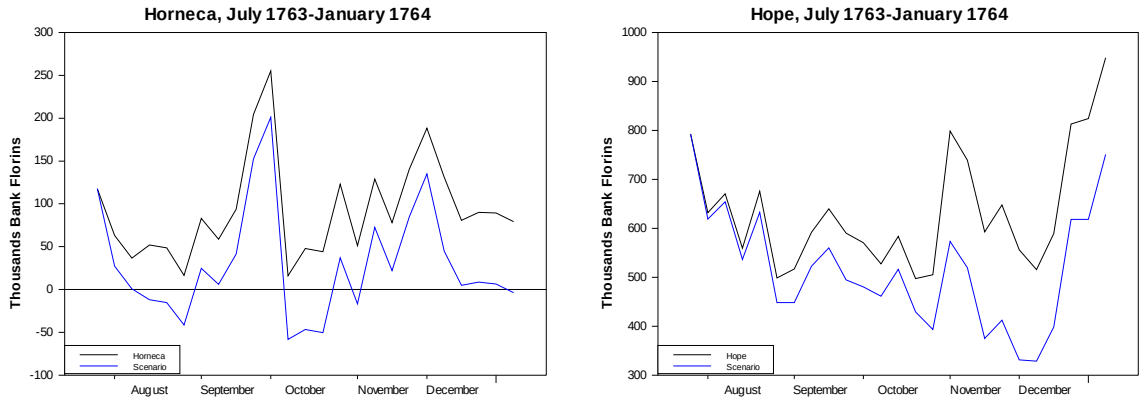


Source for both figures is Stadsarchief Amsterdam 5077.

7.4 Knock-on effects

If there had been no bullion window and if Cazenove and Smeth had failed, would additional banks have failed? To analyze this issue, we employed the simulation methodology of papers in the "contagion" literature.[46] To apply this methodology, we again interpret the post-Neufville payments data X_{ijt} as a set of obligations predetermined at the outset of the crisis.[47] A hypothetical sequence of balances is then constructed by taking initial balances at the outbreak of the crisis, and removing inflows from the bullion window, as well as payments due to and due from failing banks (Cazenove & Smeth). This exercise indicates that two other banks would have experienced noticeable impacts, Horneca Hogguer and Hope.

Figure 10: Simulated balances with no bullion window + 2 failures



Source: Stadsarchief Amsterdam 5077.

Figure 10 contrasts the evolution of balances under the contagion scenario against their realized values in the data. The simulation has Horneca Hogguer (Figure 6 above) becoming illiquid during the week of August 8. Assuming that bank accelerated its deposit of 130,000 bank guilders worth of coins from late to early August, Horneca Hogguer would still have needed 50,000 additional bank guilders to meet its payment obligations.

[46] See e.g., Upper (2007) or Mistrulli (2011) for expositions of this methodology.
[47] As in the earlier exercises, this is partly justified by an appeal to usance conventions. I.e., after the Neufville failure, banks were able to whittle down new settlement obligations by protesting bills, so what was left was the stock of bills that had already been accepted—or that the bankers felt they had to accept in order to stay in business.

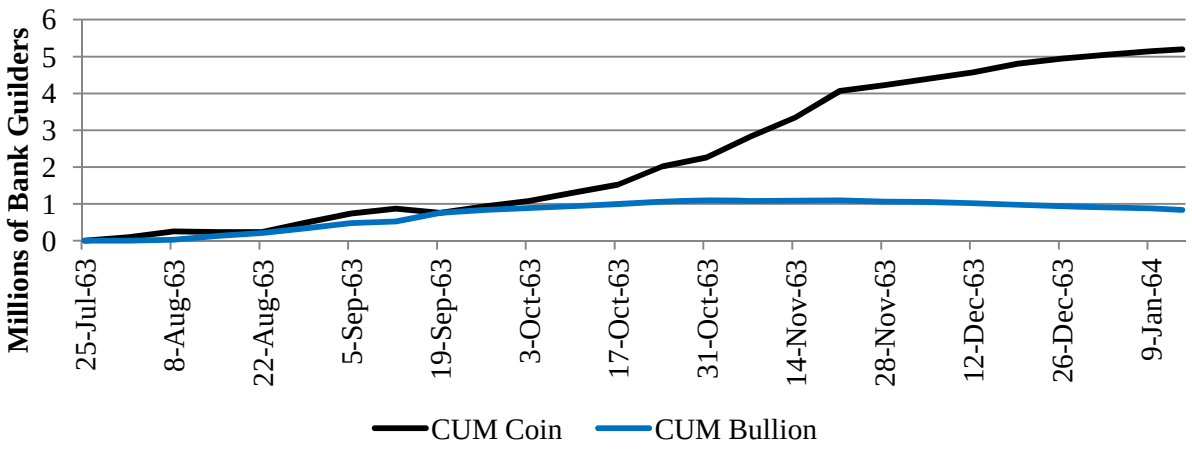
Of the remaining four banks, the biggest effects are for Hope, with a cumulative reduction in balances of about 200,000 guilders.[48] This loss comes primarily late in the year, however, so the number serves as more of an upper bound than a point estimate of the loss. Buist (1974, 520) puts the capital of Hope en Compagnie at 4.6 million current guilders in 1763, suggesting that Hope would have easily absorbed shortfalls stemming from the failures of additional parvenus, so long as asset liquidation was not a problem.[49] Nonetheless, even for Hope, 200,000 guilders would have been a considerable sum, equal to 44 percent of the firm's distributed profits for the year (Buist 1975, 521).

The above exercise does not calculate additional knock-on failures within the rest of the Bank of Amsterdam. This is a limitation of our data, but the Neufville experience suggests that more bankruptcies likely would have resulted, both within Amsterdam and abroad. It is probable that the bullion window succeeded in stopping an additional batch of failures, even if we do not know the number and magnitude of these. For example, Figure 11 plots the cumulative position of the coin window use and the bullion window use by the rest of the Bank.[50] From July 29 to September 26, the rest of the Bank used each facility in similar amounts, 931,000 bank guilders for coins and 837,000 for bullion. So during the crisis, the rest of the bank brought in 43 percent of the coin that the bankers did, yet they brought in 167 percent of the bullion. Some non-bankers appear to have had a greater need for the bullion window than did the bankers.

<Figure 11 follows next page.>

[48] This figure does not change by very much if we assume that Horneca Hogguer also fails.
[49] This inference is buttressed by Hope's offer to contribute half a million guilders to a bailout fund that was proposed at the beginning of the crisis (Dillen 1922, 249).
[50] The rest of the Bank's net position had been stable for months prior to Figure 10

Figure 11: Two cumulative positions for the rest of the Bank, by week.



Source: Stadsarchief Amsterdam 5077.

Figure 11 also shows that non-banks stopped using the bullion window after worst effects of the banking crisis in Amsterdam had passed. Outside, however, the Panic of 1763 only served to mark the beginning of a deep and long recession, most notably in Prussia (Schnabel and Shin 2004, 945-946). One consequence of the lingering effects of the crisis seems to have been a "flight to quality": net coin flows into the Bank of Amsterdam surged by 4.1 million bank guilders in the fourth quarter, and the Bank reached its two-century maximum balance of 30.9 million bank guilders (Dillen 1925, 962-6). While 18 percent of the last-quarter surge were *ryxdaalders* (likely newly minted), almost all the rest were Spanish dollars.[51] The fact that this tsunami of silver receded the next year[52] suggests to us that the crisis forced many non-bankers into direct liquidity creation in order to settle existing obligations – including debts with a maturity of three or more months when the crisis struck.

7.6 Paths not taken

A modern observer might ask why the Bank of Amsterdam did not respond to the crisis using the more familiar central banking tools of discount window lending and active open market operations.

[51] Calculated using Amsterdam Stadsarchief 5077/1390, folios 47-9.
[52] Balances had fallen to 26 million by the end of 1764 and to 16 ½ million by the end of 1765 (Dillen 1925, 996).

In the case of the former, the answer is simply that it was beyond the Bank's charter to lend to individuals or accept debt obligations (bills) as collateral. In the case of the latter, the available policy options would have worsened either the crisis inside the Bank or the crisis outside the Bank. The open market sale of coins by the Bank could lift the agio, but it would have also decreased the supply of bank guilders.[53] In addition, vault records indicate that at the time of the crisis, the Bank held only 281,804 bank guilders[54] of "unencumbered reserves" (coins not held under receipt), so a sale policy was not a realistic option. In contrast, purchases of coins would have increased liquidity within the Bank, but it would have put downward pressure on the agio. Bullion purchases[55] posed similar problems, for silver bullion was rushing to the Dutch mints. Reducing this flow would disrupt seigniorage revenue to provincial governments, disrupt the increase in the supply of current money, and disrupt the resultant recovery of the agio. By opening a bullion window, the Bank avoided these problems, while still offering a Bagehot-like balance of unlimited potential quantity at a price only the neediest would chose.

7. Lessons learned

The Panic of 1763 offers a distressingly familiar recipe for financial conflagration. Flammable ingredients include a system of securitization with numerous embedded liabilities (acceptance loans), a large shock to collateral values (the end of the Seven Years' War), and erratic policy decisions (on the part of the Prussian monetary authorities). The spark is provided by the collapse of a single participant (Neufville) who is "too interconnected to fail" (in the view of Hamburg petitioners), but who fails nonetheless. Missing from the mix are the too-big-to-fail distortions of modern financial environments, but these were hardly necessary in the lightly regulated world of eighteenth-century finance.

[53] Mees (1838, 109) argues that the Bank also feared that coins used to purchase Bank florins would quickly be shipped abroad, depriving Amsterdam of needed collateral.
[54] Calculated using Amsterdam Municipal Archives 5077/1390, folios 0, 3 and 43. See Appendix C.
[55] In the seventeenth Century, the Bank bought and sold bullion through open market operations (Quinn and Roberds 2010), but by the eighteenth century, its purchases consisted primarily of single-guilder coins that had no collateral rights at the Bank.

The Bank of Amsterdam's firefighting efforts also displayed a light touch—by the standards of 2008—but our evidence shows that they were effective within the confines of the Amsterdam market. Unlimited amounts of liquidity were made available, on fixed terms, through the Bank's traditional (coin) repo window, a type of policy that would be repeated 245 years later. A second window was opened for less conventional assets (bullion). This window was lightly used, yet it was well designed for its limited purpose. It assisted a central niche of market participants, and did not disrupt adjustment processes occurring outside the Bank.

The two liquidity facilities, working in combination, prevented additional failures of major market participants, and contained the domestic fallout from the crisis. The Bank's victory was only partial, however, because it could not route liquidity to where it was needed most—to outlying localities where the flow of trade credit depended on access to the Amsterdam market. This policy failure was compounded by a lack of finality in financial transactions, leading to chains of defaults and a complete shutdown of credit in some areas.

This mixed record leads to the following implication for understanding the effectiveness of the post-Lehman policy interventions: that the success of these efforts may not have been attributable to the ingenious design of specific facilities, or the sheer mass of liquidity offered up. Rather, the key elements may have been what northern Europe lacked in August 1763: robust settlement institutions and the free flow of liquidity across national borders.

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Appendix A: Additional table.

Table 3: Overview of Bank of Amsterdam transactions, January-July 1763

(units are thousands of bank florins unless otherwise indicated)

Merchant bank (account *j*)	Mean weekly starting balance $T^{-1}\sum_t B_{jt}$	Number debit entries, account *j*	Mean weekly interbank[56] debits $T^{-1}\sum_t \sum_{i=1}^{9} X_{ijt}$	Mean coin withdrawals $T^{-1}\sum_t X_{10,jt}$	Mean coin deposits $T^{-1}\sum_t X_{j,10,t}$	Mean total debits $T^{-1}\sum_t \sum_{i=1}^{10} X_{ijt}$	Mean ratio debits / balances $T^{-1}\sum_t \left(\sum_{i=1}^{10} X_{ijt}\right) / B_{jt}$
Hope & Compagnie	439.3	2151	448.2	25.7	24.2	473.9	1.12
Andries Pels & Zoonen	359.7	1485	220.8	25.0	0.0	245.8	0.70
George Clifford & Zoonen	277.1	1819	368.9	23.4	1.9	392.3	1.49
Gebroeders de Neufville	103.3	1395	239.3	2.0	0.4	241.3	2.69
Vernede & Compagnie	99.0	1204[57]	179.2	0.4	1.4	179.5	2.75
Raymond & Theodoor de Smeth	77.7	799	153.8	10.8	0.0	164.5	2.57
Horneca Hogguer & Co.	69.7	987	134.0	12.8	1.0	146.7	2.51
Charles & Theophilus Cazenove	68.7	1351	224.4	3.3	0.0	227.7	4.25
Total 8 large banks	1,494.5	11,191	1968.6	103.4	28.9	2071.7	
(Rest of the Bank accounts)	21,686.0		1811.3[58]	114.0	150.5	1925.3[59]	

[56] "Interbank" refers to transactions between private accounts that do not involve the flow of metal into or out of the Bank.
[57] Authors' estimate.
[58] Sum of transfers to eight most active accounts.
[59] Sum of coin withdrawals plus transfers to eight most active accounts.

Appendix B. Calibration of the Bech-Chapman-Garratt model

	January-July 1763			
Firm	Empirical liquidity distribution, in percent	Fitted value of θ	Implied distribution: naïve model ($\theta = 0$), percent	Implied distribution: fitted model, percent
Hope	1.9	.54	13.7	1.9
Pels	1.6	.54	6.9	1.0
Clifford	1.2	.54	11.3	1.6
Neufville	0.4	0	3.8	0.5
Vernede	0.4	0	2.7	0.3
Smeth	0.3	0	2.4	0.3
Horneca Hogguer	0.3	0	2.1	0.3
Cazenove	0.2	0	3.5	0.5
Rest of the Bank	93.6	.96	53.5	93.6

	August 1763-January 1764			
Firm	Empirical liquidity distribution, in percent	Fitted value of θ	Implied distribution: naïve model ($\theta = 0$), percent	Implied distribution: fitted model, percent
Hope	2.3	.69	15.5	2.5
Pels	2.5	.69	9.0	1.5
Clifford	1.3	.69	11.9	1.9
Vernede	0.2	0	2.9	0.3
Smeth	0.3	0	1.8	0.2
Horneca Hogguer	0.3	0	3.1	0.3
Cazenove	0.2	0	3.8	0.4
Rest of the Bank	92.8	.97	52.0	92.8

Appendix C. Data

I. Construction of payments data

Data regarding the account activity of the eight merchant bankers at the Bank of Amsterdam are derived from the original, extant records kept at the Amsterdam Municipal Archive (*Stadsarchief Amsterdam*) inventory number 5077. These accounts allow us to construct a weekly matrix of gross flows between each banker, the other account holders (rest of the Bank, or ROB), and the Bank itself.

A. Merchant Bankers

For the fiscal year 1763, the bank account of each of the eight merchant bankers was photographed. The accounts were substantial. For example, Hope & Co.'s account ran 39 folios during the second half of 1763. The ledger inventory numbers are 5077/ 440, 441 and 442 for 1763a (Jan-Jul); and 5077/443, 444 and 445 for 1763b (Aug-Jan 1764). To expedite processing, we limited our focus.

- We calculated the gross flows into and out of each account by week. This was expedited by the fact that the Bank calculated cumulative debts and cumulative credits every 5 transactions. The Bank only netted debits and credits when transferring a banker's balance to a new folio.
- We then examined each transfer payment and recorded those to or from another merchant banker. After repeating this for all eight bankers, we cross-referenced the transactions to double check our results and identify errors.

B. Bank of Amsterdam

To detail changes in the stock of bank money and how those changes occurred, we photographed and reconstructed two sets of accounts.

1. Specie Kamer ("coin room" or master account)

One set of accounts record the creation and destruction of bank guilders. The creation of bank guilders through the deposit of collateral/creation of receipts was recorded under the title of the bank officers receiving the coin. In 1763, these receivers were Willem van Housen (5077/441 and 444) and Hendrik Graauwhart (5077/442 and 445). All other

transactions that altered the quantity of bank money were recorded in a type of master account called the Specie Kamer (5077/441 and 444). It records 1) bank guilder destruction such as withdrawals via receipt, fee payments, interest payments, loan repayments and open market sales and 2) non-receipt bank guilder creation such as loans and open market purchases.

2. Collateral Book (*Groetboeken van de Specie Kamer*)

A different set of accounts (5077/1390) detail the flow of coins and bullion into and out of the Bank in the fiscal year 1763. This book records the coin surrendered to the Bank in order to create bank guilders and a receipt, the coins repurchased from the Bank, and the interest paid to execute or rollover receipt options. The book also records bullion flows, but not bullion fineness.

C. Rest of the Bank

We calculated the Rest of the Bank as the remainder of flows into and out of the individual accounts unaccounted for by other merchant bankers or by the Bank of Amsterdam.

II. Analysis of the bullion window

On August 4, 1673, the AWB authorized a repo window for silver bullion (Dillen 1925: 412). The bank set the minimum collateral amount at 10,000 bank guilders. Depositors got a standard receipt at a 0.5 percent repurchase/renewal rate.

The bank scaled silver bullion's price by fineness. To see this, Table C1 standardizes the various fineness rates on a bank-guilders-per-mark-pure-silver scale. We call this the bank price, for it is analogous to a coin's mint price. The differences being that the bank price delivered Bank (fiat) money of account instead of coins. Also, the Bank did not charge a fee to produce bank guilders. Instead, it charged a fee to destroy them. The price scale gave customers an incentive to cast silver to a fineness of 11/12'ths. Extant sources do not record the fineness of bullion actually received, so our analysis assumes silver bullion presented to the window had a fineness of 91.7 percent.

Table C1. Silver bullion's bank price

Fineness		Bank Guilders per Mark	Bank Guilders per Mark Pure Silver
11/12	91.7%	21	22.91
10/12	83.3%	19	22.80
9/12	75.0%	17	22.67
8/12	66.7%	15	22.50
7/12	58.3%	13	22.29
6/12	50.0%	11	22
5/12	41.7%	9	21.60
4/12	33.3%	7	21
3/12	25%	4.5	18

Source: Dillen (1925, 412).

Those holding silver bullion had other ways to gain bank guilders, so the new facility had to strike a balance between effectiveness and destabilization. It needed a price point that could help alleviate the liquidity crisis while not creating an incentive to avoid the minting of coins, or worse, the melting of existing coins. To check this, we will consider two alternative ways to convert bullion into bank guilders through Dutch mints. One could mint bullion and then purchase bank guilders on the agio (secondary) market. Or, one could mint bullion and then use the bank's repurchase facilities.

A. Options to acquire liquidity: mint bullion

1. Mint bullion and buy bank guilders

The rate at which bullion can be converted (coined) into current money is called the mint price, and customers seek the highest mint price available. In 1763, most large silver coins in the Dutch Republic had a mint price of 25.1 current guilders per mark pure silver (Polak 1998). Denote the agio percent rate as *a*. Minting bullion and then selling the resulting coin on the agio market would produce the same bank guilders as the bullion window if

$$25.1 \times \left(\frac{1}{1+a} \right) = 22.91, \text{or } a = .0956$$

So the bullion window would not disrupt minting incentives unless the agio was above 9.56 percent.

The exception to the common mint price was the Zeeland *ryxdaalder*. To promote its own mint business, the province of Zeeland set their price floor above that used by the rest of the Dutch Republic. Zeeland increased the legal value of their *ryxdaalder* (introduced in 1659 at 2.5 current guilders), to 2.55 in 1672, 2.6 in 1747, and 2.65 in 1762 (Polak 1998, 73). In turn, arbitrage caused the market price of Zeeland *ryxdaalders* throughout the Republic to follow (Polak 1998, 202). If the Zeeland *ryxdaalder* held its value in Amsterdam, then its mint price of 26.127 would outperform the bullion window for any agio up to 14 percent.

2. Mint bullion and repo at the coin window

Some Dutch coins had repurchase ("repo") windows at the Bank, and the bank guilder values the Bank assigned those coins meant that minting coins and then repoing them was always superior to the bullion window. To see this, Table C2 calculates the number of coins in a mint price, and then multiplies that number by the bank guilders per coin the Bank offered. Again, people sought the highest "bank price" for their bullion. The *ryxdaalder* offered the most at 24.10 bank guilders per mark pure silver, and that price exceeds the 22.91 offered bullion, so the bullion window did not alter long-term incentives to mint-and-repo.

Table C2. Specifics of Dutch coins with Bank repo windows

	Ryxdaalder	Zeeland *Ryxdaalder*	*Ducat*	*Drie Gulden*
Mint Price (current guilders per mark fine silver)	**25.1**	**26.127**	**25.1**	**25.1**
Current Guilders Per Coin	2.5	2.65	3.15	3
Coins per Mark at Mint Price	10.04	9.86	7.97	8.37
Bank Guilders per Coin	2.4	2.4	3	2.85
Bank Price Bank Guilders Per mark of fine silver (via a mint)	**24.10**	**23.66**	**23.91**	**23.85**

We should note that the Zeeland *ryxdaalder* was particularly unattractive for mint-and-repo, for the substantial seigniorage the province took during minting meant that Zeeland *ryx-*

daalders had an unfavorable bank price in Amsterdam, and we find no evidence of Zeeland *ryxdaalders* in the bank's vaults.

Finally, whether mint-and-buy or mint-and-repo offered the best deal depended on the market agio. The *ryxdaalder* bank price equals mint-and-sell when agio was 4.15 percent, so, for newly minted coins, the Bank's window offered a superior bank price to the secondary market when the agio was greater than 4.15.

B. Another option to acquire liquidity: sell bullion

The bullion window at the AWB, however, could become attractive if people did not have time to mint bullion. In the short run (defined as not having time to mint bullion), one could sell bullion at its market price and then use the agio or use repo. This section shows that the bullion window could become the best alternative if the agio and the price of bullion were unusually low.

1. Sell bullion and buy bank guilders

To be used at all, the bullion window had to improve on the secondary market, for resale was the fastest and most used way to gain bank guilders. Define θ as the price to sell one mark of pure silver for current guilders. The bullion-market-and-agio-market value of silver is equal to the bullion window when:

$$\theta\left(\frac{1}{1+a}\right) = 22.91$$

2. Sell bullion and repo the coins

The final path from bullion to bank guilders was selling bullion for collateral acceptable to the Bank, and then repoing that collateral at the bank. To calculate the bank guilders per mark for sell-and-repo, one needs

- θ, the current price of a mark of bullion

- the implicit agio per coin ($\bar{a}$).

The bank guilders per mark bullion becomes $\theta \frac{1}{(1+\bar{a})}$.

For any θ, customers seek the lowest implicit agio, but the implicit agio varied by coin. The implicit agio is the ratio of current guilders per coin in Table C3 over the bank guilders per coin in Table C2.

Table C3. Implicit agio by coin

	Ryxdaalder	*Ducat*	*Drie Gulden*
1. Current guilders per coin	2.5	3.15	3
2. Bank guilders per coin	2.4	3	2.85
3. Implicit Agio (row 1 / row 2)-1	4.1%	5%	5.2%

Of the Dutch coins, the lowest implicit agio was the *ryxdaalder*, so the bullion window offered the same bank guilders as selling bullion for *ryxdaalders* (and then repoing them) when

$$\theta \frac{1}{(1+\bar{a})} = 22.91, or\ \theta = 23.86$$

So, if the price of bullion fell below 23.86, then the bullion window was superior to sell-and-repo. That bullion price threshold, however, assumes no money changing fees. It also assumes that the price of coins did not rise above their ordinance price-floors, so the threshold could easily have been higher depending on market conditions.

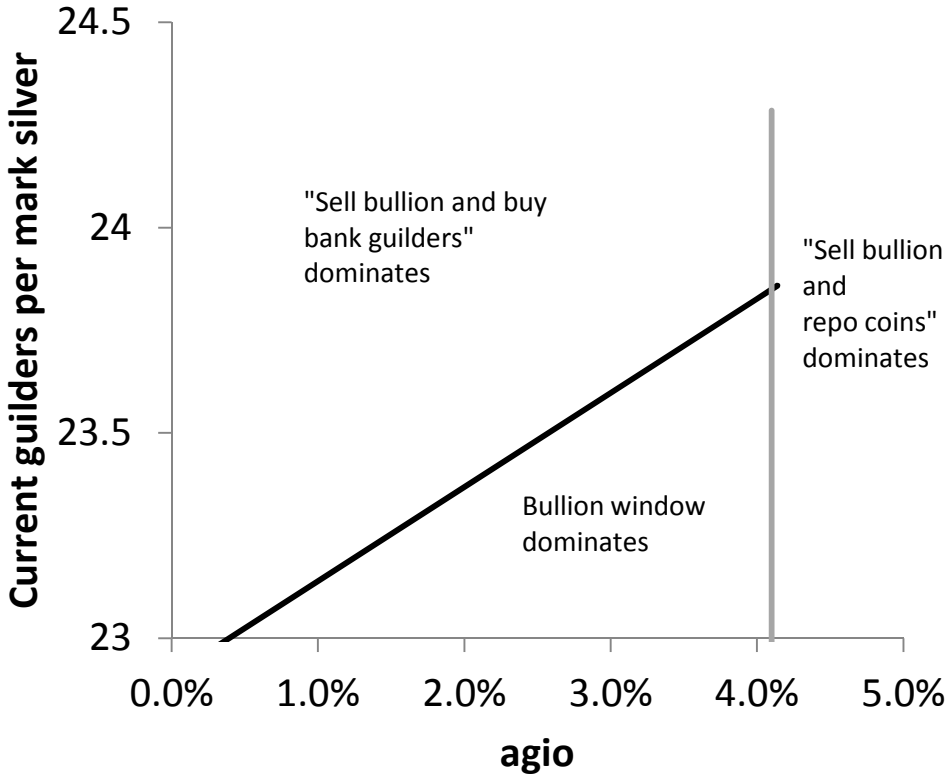
C. Acquiring liquidity through the bullion window

We conclude that the bullion window had no effect on long-run incentives to mint bullion. It could, however, offer a dominant the bullion secondary market in the short-run channel *if* the price of silver bullion (θ) and the agio (a) were low by historical standards.

The bullion window was superior to sell-and-repo if $\theta < 23.86$, and it could also be superior to sell-and-buy for if the agio caused $\theta \frac{1}{(1+a)} < 22.91$. To see the range of silver-agio pairings that could dominate, consider Figure C1. The price of silver (θ) is on the vertical axis, and the agio is on the horizontal. Any sell-bullion-and-buy-bank guilders price combination is a point in this space. The "sell bullion-repo coins" threshold is in grey. The "sell bullion – buy bank guilders" threshold is in black. The area bounded by the thresholds, labeled "silver window," gives the set of market conditions that would make the silver window the best option for those seeking to convert silver bullion into bank guilders.

While it is possible that the bullion window could dominate the bullion market, we have found no evidence that bullion prices were ever low enough. Only severe market frictions could have been brought this about. Instead, we conclude that the window was targeted at people seeking to make immediate use of silver bullion as collateral.

Figure C1. Conditions for the bullion window's superiority



III. Analysis of Vaaten silver deposits

In September 1763, a merchant named Benjamin Veijtel Ephraim used the bullion window to transform silver bullion into bank money payments to a few bankers. We consider this money as banker liquidity gained through the bullion window. This section explains what happened.

Benjamin Veijtel Ephraim was a member of a German Jewish family that supplied silver to the Prussian mints (Koser 1900). In installments on September 8, 10 and 13, Ephraim brought 364,864 bank guilders worth of bullion to the bullion window (5077/1390, f. 30). The operation, however, was unique in a number of ways.

The Bank gave this bullion the title *vaaten* (barrel) silver, presumably because it arrived in barrels. All other bullion deposits were labeled *baeren* (bars). Although Ephraim took the receipts for the *vaaten* silver, he did not get the bank guilders. Rather, the Bank created, and directly credited a special purpose account just for this money. The account was jointly held by three merchant bankers (Andries Pels & Zoonen, George Clifford & Zoonen , and Raymond & Theodor de Smeth) and one potential banker (Harmen van de Poll).

No sooner had the money arrived than it was dispersed to the owners, a prominent bullion merchant, and Ephraim himself. Table C4 reconstructs these transactions and shows how we accounted for them.

Our interpretation of these events is that Ephraim owed these bankers money, and this was an acceptable way to pay them. We suspect this based on the approaches not taken. Ephraim could have had the funds credited to his own account, but then the bankers would have had to rely on him to transfer the funds to their account. The fact that a residual 16,000 went to Ephraim's account underscores that he got what was left.

Alternately, Ephraim could have given the silver to the bankers. That he did not sell the silver suggest that market prices were low and expected to recover. That he did not give the silver over as private collateral suggests that either market terms were less attractive than the bullion window or that the bankers preferred to let the Bank handle the collateral.

Finally, we know that Ephraim retained the receipts for the deposited silver, for he began repurchasing the *vaaten* silver starting on November 3 (5077/1390, f. 31; 5077/443, f. 141). Again, the

bullion receipts had a relatively large haircut and high rate, so he had an incentive to unwind his repurchase agreement.

Table C4. The *vaaten* silver operation

Bullion credits to the joint account of "Pels, Clifford, Smeth and van de Poll"		**Debits from the joint account**		**To the account of**	**Treated as bullion funding for**
Sept. 8	151,534.5	Sept. 9	20,000	van de Poll	Rest of Bank
			20,000	Smeth	Smeth
			59,999.85	Pels	Pels
Sept. 10	193,732	Sept. 12	58,000	van de Poll	Rest of Bank
			48,000	Clifford	Clifford
			70,000	Moses Philip	Rest of Bank
			60,000	Smeth	Smeth
Sept. 13	19,597.5	Sept. 14	16,000	Benjamin Veijtel Ephraim	Rest of Bank
			12,700	Pels	Pels
Total	364,864		364,699.85		

Sources: Stadsarchief Amsterdam 5077/443, f. 14 and 5077/1390, f. 30-1.

IV. Mint Activity

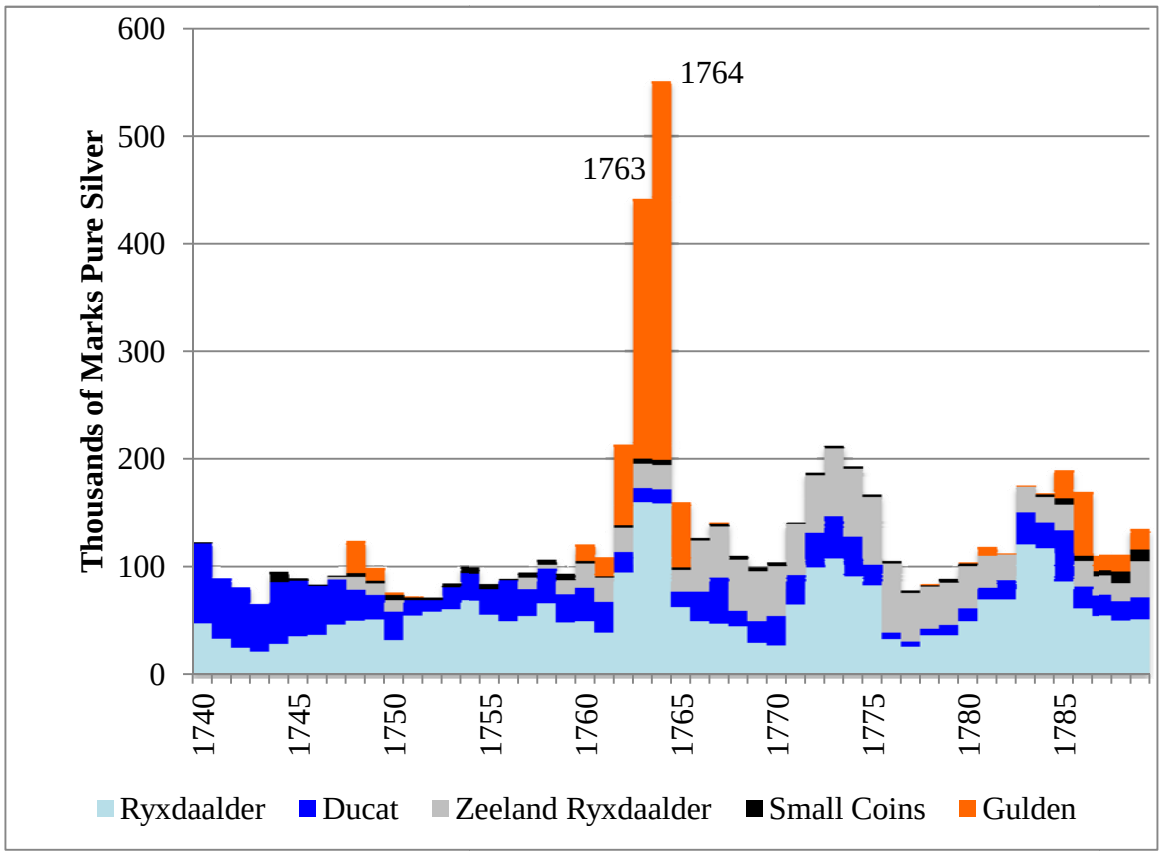
In the monetary system of the Dutch Republic, a silver bullion price below 25.1 current guilders per mark pure silver would encourage minting. In 1763-4, there, was a great deal of minting. Figure A2 shows the production of silver coins at the Republic's six provincial mints from 1740 to 1798. The series has two caveats. It is smoothed because mint report periods were irregular, so we cannot be more specific regarding when the surge began and ended. The series is also occasionally incomplete, so it is a minimum.

The spike in 1763-4 dwarfs previous years. The two year total of about 1 million marks translates into roughly 25 million current guilders. That *flow* is approximately the same size as the Bank of Amsterdam's *stock* of metal, and only 1 to 2 million of that production moved directly to the Bank.

In normal times, the dominant coin produced was the *ryxdaalder*: a coin used for international trade. Again, the *ryxdaalder* had a superior implicit agio than other Dutch coins (see Appendix Table C3). Zeeland *Ryxdaalder* production (for domestic use) is in grey, and its production clearly increased with the provincial price floor increases in 1747 and 1762.

The crisis, however, also brought a surge in the *gulden* production. The *gulden* had no repo window at the Bank and was not used for export, so evidently many people wanted coins to make current guilder payments in the domestic economy rather than payments inside the bank or for international trade. The mint numbers suggest that the Panic of 1763 particularly disrupted the domestic Dutch payment system.

Figure C2. Mint production of silver coins, 1740 to 1789



Source: Derived from Polak 1998.

V. Accounts of other bankers, July 1763-January 1764

These are the balances and cumulative positions for bankers not pictured in the paper.

Figure C3. Weekly balances of Pels

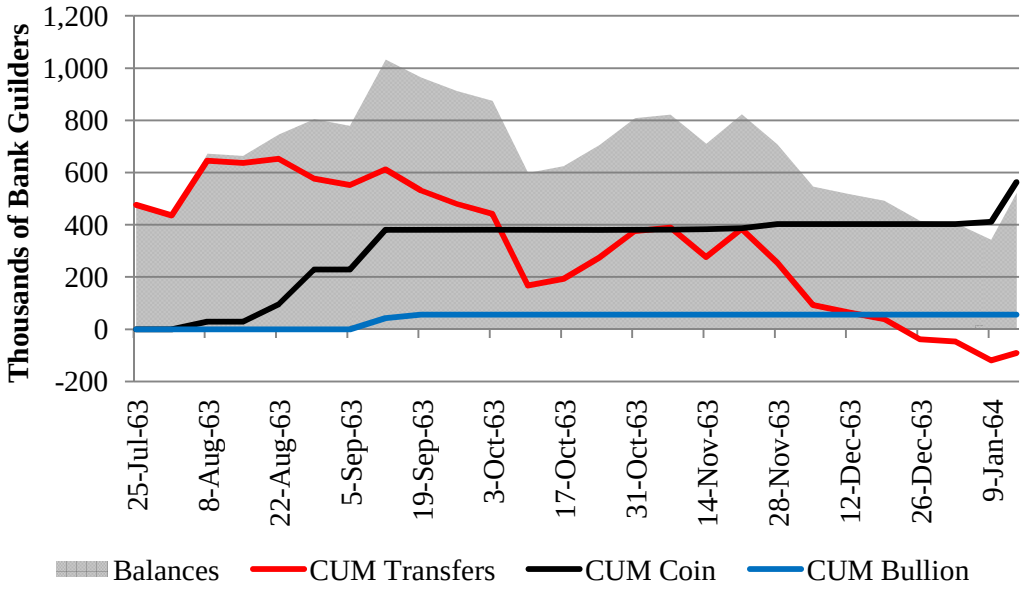


Figure C4. Weekly balances of Clifford

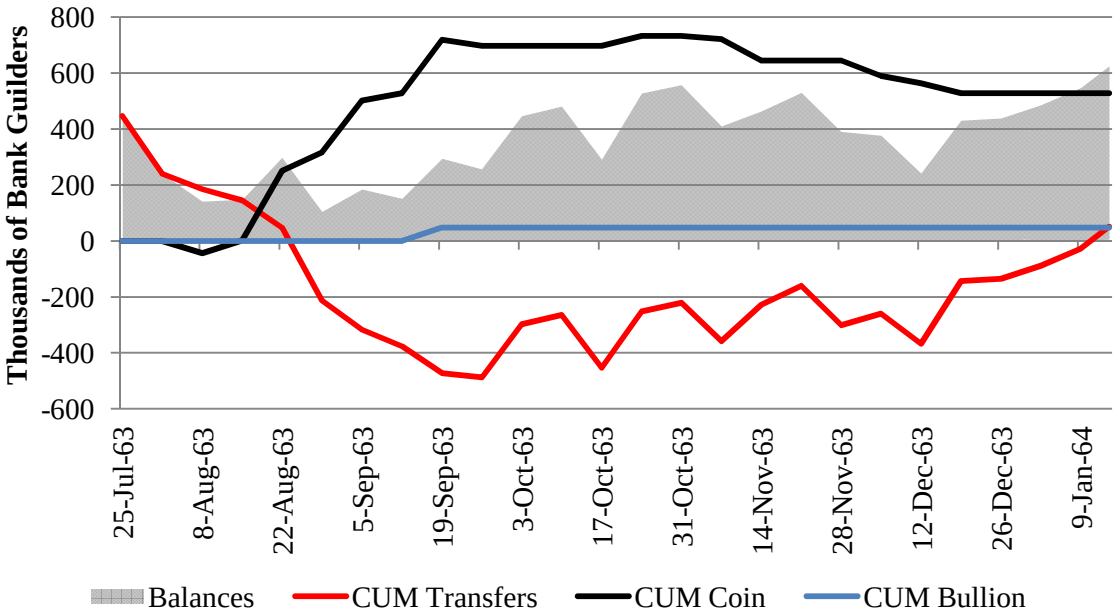


Figure C5. Weekly balances of Hope

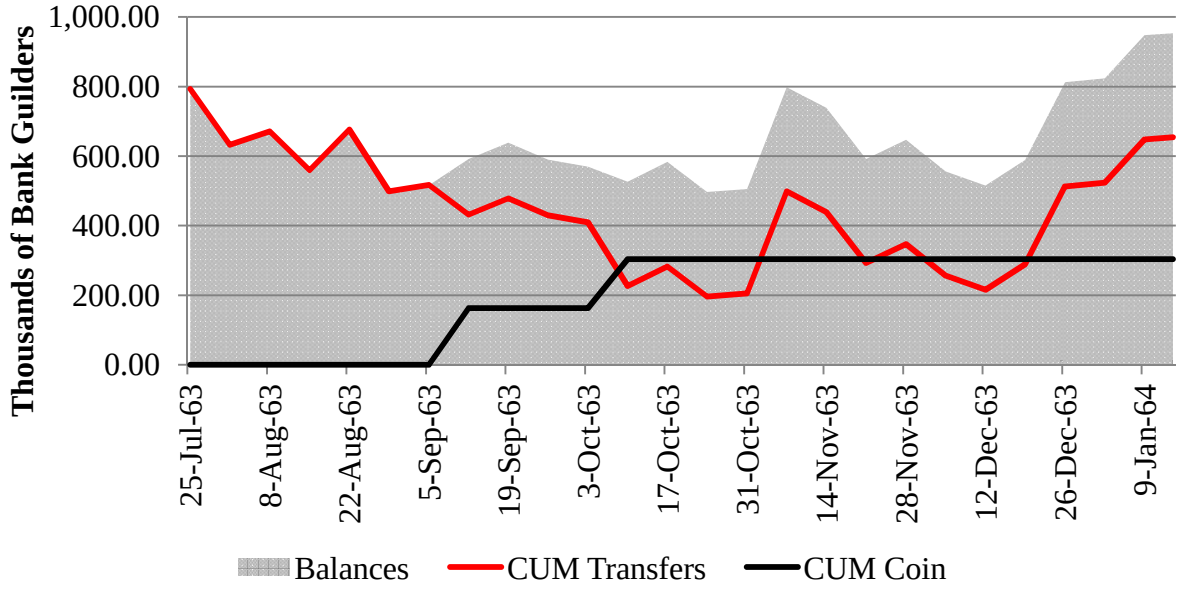
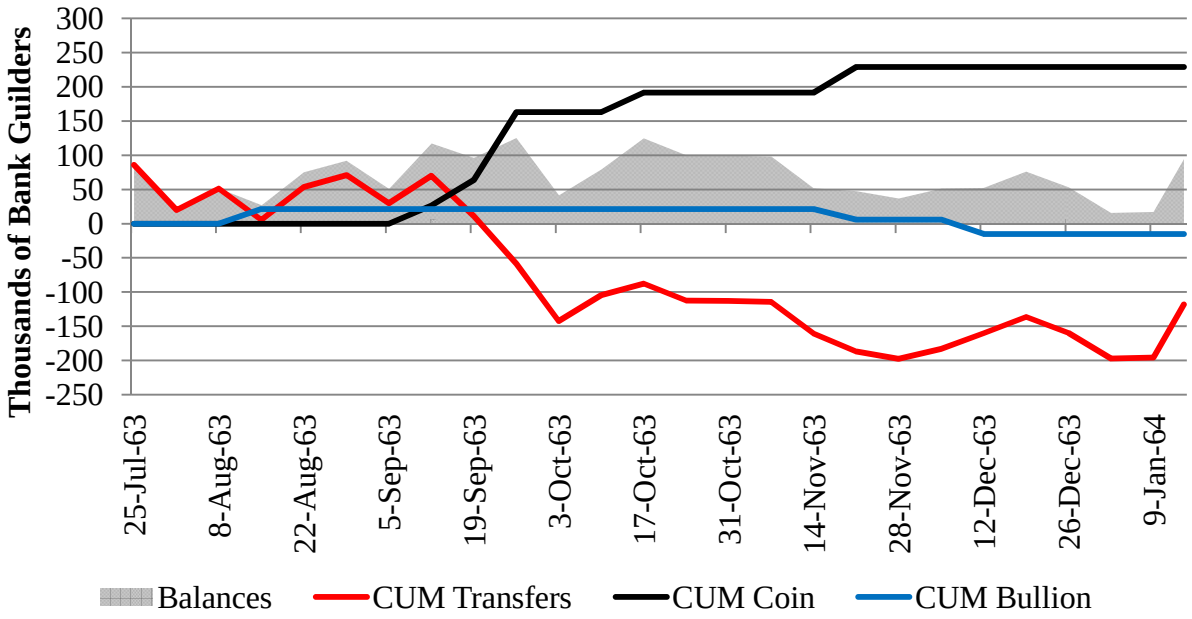


Figure C6. Weekly balances of Vernede



VI. Bank of Amsterdam Balance Sheet

Table C5. Bank of Amsterdam Balance Sheet for Fiscal Year 1763, by week in bank guilders

Date			ASSETS		LIABILITIES	CAPITAL
Start	Week	TOTAL	Metal	Loans	Accounts	
28-Jan-63	1	23,120,636	22,893,372	227,264	22,945,231	175,405
31-Jan-63	2	23,180,956	22,953,692	227,264	23,002,323	178,633
7-Feb-63	3	23,177,201	22,949,937	227,264	22,994,333	182,868
14-Feb-63	4	23,152,841	22,925,577	227,264	22,965,734	187,107
21-Feb-63	5	23,180,901	22,953,637	227,264	22,992,525	188,376
28-Feb-63	6	23,129,321	22,902,057	227,264	22,942,009	187,311
7-Mar-63	7	23,677,121	23,449,857	227,264	23,556,140	120,981
14-Mar-63	8	24,291,006	24,063,742	227,264	24,205,654	85,352
21-Mar-63	9	24,252,486	23,925,222	327,264	24,139,929	112,557
28-Mar-63	10	24,464,586	24,037,322	427,264	24,258,772	205,813
4-Apr-63	11	24,238,376	23,811,112	427,264	24,038,524	199,851
11-Apr-63	12	24,389,116	23,961,852	427,264	24,188,447	200,669
18-Apr-63	13	23,961,316	23,734,052	227,264	23,754,320	206,996
25-Apr-63	14	23,620,976	23,393,712	227,264	23,372,356	248,620
2-May-63	15	23,242,331	23,015,067	227,264	23,174,987	67,345
9-May-63	16	23,241,531	23,014,267	227,264	23,198,377	43,154
16-May-63	17	23,182,131	22,954,867	227,264	23,153,277	28,854
23-May-63	18	23,023,651	22,796,387	227,264	22,982,126	41,525
30-May-63	19	22,985,711	22,758,447	227,264	22,936,736	48,976
6-Jun-63	20	22,906,991	22,679,727	227,264	22,704,553	202,439
13-Jun-63	21	22,691,791	22,464,527	227,264	22,645,234	46,558
20-Jun-63	22	22,377,951	22,150,687	227,264	22,329,660	48,291
27-Jun-63	23	22,193,311	21,966,047	227,264	22,224,267	-30,956
4-Jul-63	24	22,068,651	21,841,387	227,264	22,314,777	-246,126
11-Jul-63	25	22,176,156	21,848,892	327,264	22,298,864	-122,708
18-Jul-63	26	22,295,163	21,767,899	527,264	22,244,207	50,956
29-Jul-63	27	22,295,163	21,767,899	527,264	22,344,207	-49,044
1-Aug-63	28	22,422,388	21,895,124	527,264	22,660,145	-237,757
8-Aug-63	29	22,826,928	22,199,664	627,264	22,940,267	-113,338
15-Aug-63	30	23,361,975	22,534,711	827,264	23,414,273	-52,298
22-Aug-63	31	23,917,410	22,990,146	927,264	24,024,037	-106,626
29-Aug-63	32	24,804,943	23,677,679	1,127,264	24,668,294	136,649
5-Sep-63	33	25,770,675	24,643,411	1,127,264	25,438,106	332,569
12-Sep-63	34	26,521,899	25,394,635	1,127,264	26,398,435	123,464
19-Sep-63	35	26,750,906	25,623,642	1,127,264	26,681,862	69,044

26-Sep-63	36	27,227,297	26,100,033	1,127,264	27,046,318	180,979
3-Oct-63	37	27,512,605	26,385,341	1,127,264	27,318,559	194,046
10-Oct-63	38	27,761,045	26,633,781	1,127,264	27,675,445	85,601
17-Oct-63	39	28,283,291	27,156,027	1,127,264	27,983,359	299,932
24-Oct-63	40	28,742,173	27,614,909	1,127,264	28,590,493	151,680
31-Oct-63	41	29,268,410	28,141,146	1,127,264	28,906,700	361,710
7-Nov-63	42	29,568,851	28,441,587	1,127,264	29,466,072	102,779
14-Nov-63	43	30,010,488	28,883,224	1,127,264	29,883,099	127,389
21-Nov-63	44	29,945,180	29,717,916	227,264	29,731,910	213,270
28-Nov-63	45	29,995,039	29,767,775	227,264	29,860,840	134,199
5-Dec-63	46	30,249,001	30,021,737	227,264	30,099,279	149,722
12-Dec-63	47	30,326,299	30,099,035	227,264	30,198,588	127,711
19-Dec-63	48	30,490,984	30,263,720	227,264	30,350,896	140,088
26-Dec-63	49	30,580,639	30,353,375	227,264	30,462,793	117,846
2-Jan-64	50	30,695,547	30,468,282	227,264	30,539,826	155,720
9-Jan-64	51	30,793,889	30,566,625	227,264	30,649,858	144,031
16-Jan-64	52	31,085,138	30,857,874	227,264	30,966,847	118,291

Table C6. Bank of Amsterdam Metal Stock in FY 1763,

by week in bank guilders

		Under Receipt				Unencumbered
		COINS			BULLION	Reserves
Week	TOTAL	Dutch	Dollars	Gold		
1	23,367,343	1,132,420	21,225,600	61,380	0	473,972
2	23,427,663	1,175,140	21,243,200	61,380	0	473,972
3	23,423,908	1,197,785	21,216,800	61,380	0	473,972
4	23,399,548	1,166,825	21,223,400	61,380	0	473,972
5	23,427,608	1,203,245	21,201,400	75,020	0	473,972
6	23,376,028	1,239,665	21,113,400	75,020	0	473,972
7	23,923,828	1,264,745	21,595,200	115,940	0	473,972
8	24,537,713	1,271,430	22,202,400	115,940	0	473,972
9	24,399,193	1,267,110	22,068,200	115,940	0	473,972
10	24,511,293	1,188,030	22,266,200	109,120	0	473,972
11	24,285,083	1,072,040	22,162,800	102,300	0	473,972
12	24,435,823	1,025,000	22,367,400	95,480	0	473,972
13	24,208,023	862,980	22,294,800	102,300	0	473,972
14	23,867,683	789,060	22,035,200	95,480	0	473,972
15	23,313,634	715,620	21,905,400	95,480	0	298,567
16	23,312,834	673,020	21,947,200	95,480	0	298,567
17	23,253,434	673,020	21,887,800	95,480	0	298,567
18	23,094,954	644,340	21,758,000	95,480	0	298,567
19	23,057,014	618,060	21,766,800	75,020	0	298,567
20	22,978,294	625,140	21,681,000	75,020	0	298,567
21	22,763,094	614,100	21,463,200	88,660	0	298,567
22	22,449,254	639,060	21,124,400	88,660	0	298,567
23	22,264,614	683,220	20,895,600	88,660	0	298,567
24	22,139,954	684,180	20,776,800	81,840	0	298,567
25	22,147,459	665,065	20,796,600	88,660	0	298,567
26	22,056,332	662,185	20,721,800	95,480	0	288,434
27	22,056,332	662,185	20,721,800	95,480	0	288,434
28	22,183,557	710,210	20,801,000	95,480	0	288,434
29	22,488,098	751,100	20,807,600	278,665	73,866	288,434
30	22,823,145	755,195	21,058,400	253,790	178,893	288,434
31	23,278,580	758,110	21,423,600	253,790	266,213	288,434
32	23,966,113	764,325	21,881,200	301,530	442,191	288,434
33	24,931,844	769,155	22,660,000	328,590	597,232	288,434
34	25,683,069	804,185	23,009,800	336,053	956,164	288,434
35	25,912,075	825,655	23,097,800	336,053	1,075,701	288,434
36	26,388,466	839,215	23,485,000	336,053	1,151,332	288,434
37	26,673,775	887,095	23,643,400	315,593	1,250,820	288,434
38	26,922,215	940,470	23,889,800	206,473	1,308,605	288,434

39	27,444,460	953,940	24,343,000	199,653	1,371,001	288,434
40	27,903,342	1,088,465	24,602,600	199,653	1,435,758	288,434
41	28,429,579	1,158,955	25,000,800	199,653	1,493,305	288,434
42	28,730,020	1,200,185	25,275,800	199,653	1,477,516	288,434
43	29,171,657	1,226,795	25,680,600	199,653	1,487,743	288,434
44	30,006,349	1,329,270	26,408,800	206,473	1,484,940	288,434
45	30,056,209	1,336,640	26,492,400	206,473	1,443,829	288,434
46	30,310,170	1,424,715	26,622,200	249,593	1,436,796	288,434
47	30,387,468	1,517,575	26,666,880	249,593	1,376,554	288,434
48	30,552,153	1,629,085	26,774,680	239,643	1,331,879	288,434
49	30,641,808	1,717,095	26,801,080	234,668	1,312,099	288,434
50	30,756,716	1,852,570	26,831,880	214,208	1,281,191	288,434
51	30,855,058	1,939,370	26,853,880	194,308	1,290,634	288,434
52	31,137,430	1,913,585	27,161,880	177,538	1,325,315	279,556