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A brief history of payment netting and settlement

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A Brief History of Payment Netting and Settlement

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Abstract:

In earlier times, societies relied extensively on “IOUs” (“I owe you”) to avert the need for settlement in specie. However, an IOU reliant economy is complex and fraught with financial stability risks. These problems can be overcome through clearing, netting and settlement, either without or with novation. From the perspective of creditors, the most expedient solution is for residual claims to be denominated in a large-scale, risk-free and divisible IOU that is analogous to settlement in specie, but without incurring the disadvantages of settlement in precious metal coins. If such solutions are not feasible, it is then desirable that (1) networks of IOUs are simplified through netting, and (2) residual claims are denominated in relatively high-quality claims, which can be readily converted into risk-free positions. The purpose of this paper is to explore how such outcomes have been achieved through the lens of history. As will be shown - whilst netting and settlement with novation is an effective technique to mitigate financial instability risks - it is only through central banks acting as correspondents to the domestic financial system that the drawbacks of the IOU economy can be alleviated to the largest extent in order to attain lean balance sheets, lower credit risk and improved financial stability. At the same time, such a solution also ensures that the financial system remains layered.

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A Brief History of Payment Netting and Settlement

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1. Introduction

Payments have been taking place since the very beginning of economic activity and have resulted in the creation of financial claims and liabilities. Claims and liabilities take various forms and evolve through the phases of a trade, i.e. (i) “pre-trade”; (ii) between trade and settlement (i.e. “post-trade”); and (iii) “post-settlement” claims and liabilities. They involve both the parties of the trade (e.g. non-financial firms and households) and in many cases, the financial institutions offering payment services and deposit accounts to them.

Initiatives to enhance efficiencies in payments have been ongoing since the first economic trade. To mitigate the inadequacies of economic activity being underpinned by barter, commodity money was introduced (see e.g. Law, 1705, chapter 1). Although the use of specie as a means of payment has the benefit of not being a claim on any counterparty,¹ it does suffer from several major drawbacks as a means of payment. First, specie is inconvenient as a medium of exchange due to cost in its storage and transportation. Second, as a finite commodity, specie as a means of payment can become very costly. Third, there remains the issue of heterogeneity of coins and debasement (and therefore adverse selection - i.e., “Gresham’s law”).

For centuries, the inconveniences of settlement in specie have been overcome through a reliance on IOUs (“I owe you”). However, the IOU economy is in itself not a panacea, as the build-up of extensive IOU networks is fraught with financial stability risks. Typically, the problems of credit-interconnectedness are three: (i) the constant necessity to record claims and liabilities; (ii) costs to monitor claims and liabilities and control counterparty credit risks; and (iii) the potential for contagion risks in the event of large credit events (see e.g. Gai and Kapadia, 2010). Early authors, such as Potter (1650, p. 39), recognised the drawbacks of credit-interconnectedness:

“[t]he greatest part of men’s returns in most places of the world, are either upon the credit of particular persons, as here in England, or else, by means of some brass or copper money made current by law, as in Spain, Holland and other places, both which are bad enough, though the former much more liable to hazard than the latter... And considering, that notwithstanding the so many and great inconveniences of trading upon such private credit, so long experienced by men of all trades and nations, it still continues so common a thing amongst them, to make use of their own words and credits, instead of money, for transferring goods to and from one another...”

¹ In this way, settlement is framed as being “ultimate”, as holdings of specie are not a claim on any counterparty. This is in contrast to financial money, which is always a claim on a counterparty, be it through commercial bank money (i.e. deposit accounts to traders, or deposit accounts between individual commercial banks), or via central bank money (i.e. deposit accounts of commercial banks with the central bank, and through the provision of banknotes).

Credit–interconnectedness nevertheless facilitates economic activity in the absence of better alternatives, as summarised by Thornton (1802, p. 75):

“Commercial credit may be defined to be that confidence which subsists among commercial men in respect of their mercantile affairs which disposes them to lend money to each other, to bring themselves under various pecuniary engagements by the acceptance and indorsement of bills, and also to sell and deliver goods in consideration of an equivalent promised to be given at a subsequent period.” The benefits of credit are many: “The day on which it suits the British merchant to purchase and send away a large quantity of goods may not be that on which he finds it convenient to pay for them.” Without credit, “he must always have in his hands a very large stock of money; and for the expense of keeping this fund (an expense consisting chiefly in the loss of interest) he must be repaid in the price of the commodities in which he deals.” Credit sets him “at liberty in his speculations: his judgement as to the propriety of buying or not buying, or of selling or not selling ... may be more freely exercised”.

One avenue to alleviate the problems of the IOU economy is through **balance sheet shortening via the clearing, netting and settlement of post–trade claims and liabilities**. Two variants of netting and settlement have to be distinguished: (i) the netting and settlement of post–trade claims without creating exposures to new debtors; and (ii) the netting and settlement of post–trade claims with “novation”, which implies that creditors accept new debtors following the settlement of any residual claims.

From the perspective of creditors, **the most expedient solution is for residual claims to be denominated in risk–free, fungible and divisible IOUs that it is analogous to settlement in specie**, but without incurring the disadvantages of settlement in precious metal coins. As acquiring such IOUs are always considered an improvement, novation is always accepted, and the drawbacks of the IOU economy can be successfully overcome. The question then becomes whether it is indeed practical for creditors to have access to prime–like IOUs that are free from any credit risks. If such solutions are not feasible, it is therefore desirable that (1) networks of IOUs are minimised through netting, and any (2) residual claims are denominated in high quality IOUs that can also be readily converted into risk–free IOUs.

The purpose of this paper is to explore how such outcomes have been achieved through the lens of history. As will be shown – whilst netting and settlement with novation is certainly an effective technique to mitigate financial instability risks – it is only through central banks acting as correspondents to the domestic financial system that the drawbacks of the IOU economy can be alleviated to the largest extent in order to attain lean balance sheets, lower credit risk and improved financial stability. At the same time, such a solution also ensures that the financial system remains layered. Although the importance of central bank money to the

financial system has been extensively explored,² this paper distinguishes itself by unpacking the numerous evolutions to achieve such a construct, namely through (1) bills of exchange; (2) early deposit banks; and (3) early central banks in combination with bills of exchange.³ Moreover, to further differentiate itself from the extant literature, this paper adopts a series of financial accounts and digraphs. By adopting such a framework, the challenges imposed by IOU networks can be readily portrayed and the implications understood.

This paper is structured as follows. Section 2 introduces the general problem of an IOU based economy, and explains the basic mechanics of clearing, netting and settlement of post-trade claims as a means to alleviate the dangers of the IOU economy. Sections 3 and 4 each explain one “private sector” solution to implement netting and settlement, namely via bills of exchange (section 3) and private deposit banking (section 4). Sections 5 and 6 explain how central banks have made each of these solutions more effective: section 5 explains the symbiosis between central banking and bills of exchange settlement, while section 6 turns to the role of central banks as meta-correspondent banks. Section 7 concludes.

2. The IOU economy, and the need for clearing, netting and settlement

Post-trade (i.e. pre-settlement) claims and liabilities typically result in a lengthening of balance sheets. This therefore imposes additional risks and exposures, which last from the period at which the trade is struck at time “T” until all post-trade claims and liabilities are eliminated because of settlement at some point in the future at time “T + t”. In an ideal scenario, counterparty credit risks can be minimised through an efficient, secure settlement medium.

Although cumbersome, **the adoption of specie as a settlement medium was revolutionary.** Through settlement in specie, post-trade claims and obligations were able to disappear **without recourse to the creation of new claims and liabilities.** It is in this sense that settlement through specie can be considered to be ultimate, and leads to creditors acquiring stocks of some precious asset, be it for instance gold or silver coins. In this way, specie was able to act as a liquid store of value. Furthermore, in acting as the unit of account, specie overcame the problem of the double co-incidence of wants (e.g. 100 chickens equals 1 cow etc.).

² See e.g. CPSS (2003) and Norman, Shaw and Speight (2011).

³ For extensive accounts on bills of exchange, see Usher (1914), Read (1926), Kohn (1999a), Quinn and Roberds (2008), Anston et al (2017). For seminal works on early private and public banks, see Dean (1884), Dunbar (1892), Usher (1934, 1943), Lane (1937), Quinn (1997), De Roover (1948, 1963), Kohn (1999b, 2001), Roberds and Velde (2014, 2016), Ugolini (2016) and Bindseil (2019a, b).

However, **settlement through specie transfer is problematic**. Precious metal is scarce and using coins as means of payment suffered throughout history from adverse selection problems (e.g. Gresham's law: bad coins with less metal value push out good coins from circulation), implied costly controls (e.g. weighting coins when being used), and the high costs and risks of storage and transport. The inconveniences of ultimate settlement in precious metal coins can be overcome through the introduction of **financial money**, which combines the advantages of a reliance on IOUs whilst somewhat retaining the characteristics of settlement in specie. Under such an arrangement, post-trade claims and liabilities continue to be extinguished via settlement, but are merely substituted through the creation of new claims.

As a starting point, consider an IOU economy with “n” agents trading in “m” goods. Then “n(n-1)m” claim and liability (IOU) relationships can be generated. Agents will be willing to accumulate IOU exposures, but only up until some finite limit. Should participants begin to doubt the creditworthiness of their debtors and insist on settlement (through precious metal coins or any other goods), significant problems will occur.

One technique to minimise the complexity of the IOU network is through the netting and settlement of post-trade claims and liabilities. Broadly speaking, clearing is used to summarise all activities following a trade being agreed upon. These activities include the transmission, reconciliation and confirmation of post-trade claims and liabilities (Cox, Garvin and Kelly, 2013). Following clearing, the process of netting and subsequent settlement of post-trade claims can be distinguished across various dimensions:

- The simplest form of netting is **bilateral netting**, which involves the calculation of net post-trade claims between two counterparties starting from multiple gross claims.
- **Multilateral netting** is the calculation of net post-trade claims between three or more counterparties.⁴

The netting and settlement of post-trade claims can occur **without or with novation**:

- **Without novation** means that no creditor has to accept a new debtor as a consequence of the netting and settlement process.
- **With novation** denotes that creditors accept that their debtor changes following the settlement of any post-trade claims. That is to say, through novation, original claims are considered to be settled, and are replaced through the creation of a new claim vis-à-vis a new debtor.⁵

Netting without and with novation can be further segregated into subcategories:

- **Decentralised netting without novation**: through some instrument, such as a bill of exchange, a mutual stock of credit–interconnectedness between several participants can be reduced or eliminated.

⁴ Giovanoli (1997) notes that bilateral netting has existed since Roman times, whilst multilateral netting first appeared during the Middle Ages.

⁵ In a legal sense, claims are transferrable as long as creditor rights are upheld (Kahn and Roberds, 2007).

- **Centralised netting without novation:** an entity which is common to all participants – such as a clearinghouse – is able to register and account for all post-trade claims and liabilities and can therefore net and thereby settle a part of the credit-interconnectedness amongst all participants.
- **Centralised netting with novation:** through the concentration of claims to a debtor of high credit quality (which in tandem acts as both a clearinghouse and settlement agent), such as a central bank, significant additional potential for reducing credit-interconnectedness typically arises.

The **netting of post-trade claims** can be contemplated through the simple example below in Table 1. In this case, a number of “entities” (e.g. traders, banks) have accumulated a stock of post-trade claims and liabilities at time “T”, which are depicted in **black** (this could be in either the domestic or cross-border context). Under the **first type of netting** – that is, **decentralised netting without novation** – claims can be netted without creating exposures to new debtors, and a stock of credit-interconnectedness (in this case, a triangular “circle” of unit claims) can be netted away (as shown in **blue**). In the **second type of netting** – **centralised netting without novation** – claims are registered to a clearinghouse which is mutual to all participants. However, in this example, it is not possible for the level of credit-interconnectedness to be reduced.⁶ Finally, in the **third type of netting** – **centralised netting with novation** – netting occurs through the novation of claims to a counterparty that is common to all participants (displayed in **red**), which is an improvement on the previous two solutions. In the aftermath of netting with novation, any remaining post-trade claims can be thought of as residuals (shown in **green**).

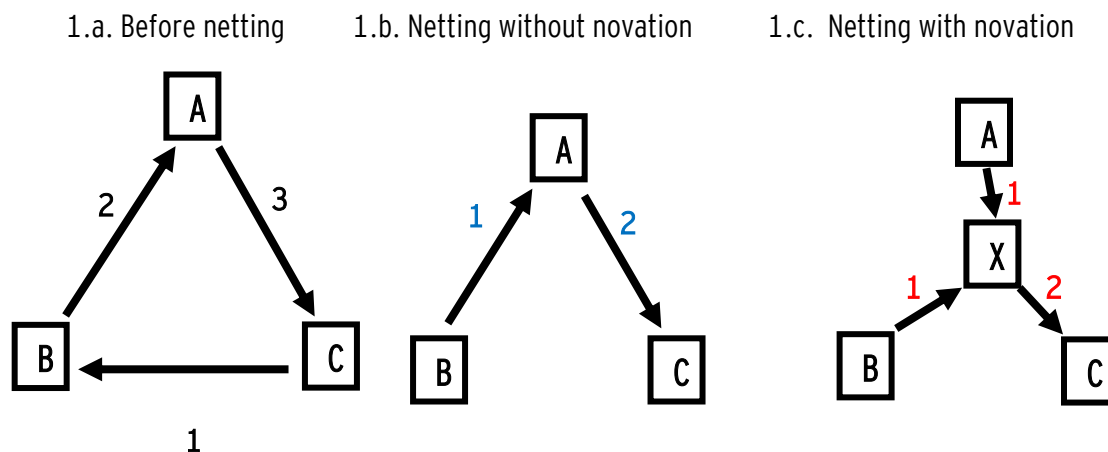
Table 1: Credit-interconnectedness, netting and settlement

Netting type	Entity A accounts			
	Assets	A	Equity	A
(1)	Claim on C	3 -1	Liability to B	2 -1
(2)	Claim on C	3	Liability to B	2
(3)	Claim on X	3 -2	Liability to X	2 -2
Residual	Claim on X	1		
	Entity B accounts			
	Assets	B	Equity	B
(1)	Claim on A	2 -1	Liability to C	1 -1
(2)	Claim on A	2	Liability to C	1
(3)	Claim on X	2 -1	Liability to X	1 -1
Residual	Claim on X	1		
	Entity C accounts			
	Assets	C	Equity	C
(1)	Claim on B	1 -1	Liability to A	3 -1
(2)	Claim on B	1	Liability to A	3
(3)	Claim on X	1 -1	Liability to X	3 -1
Residual			Liability to X	2

⁶ This is due to the fact that in the provided example no two entities are mutually indebted to one another (and hence any bilateral claims cannot be netted away). For instance, whilst entity A has a claim on entity C, it does not at the same time incur any liabilities to entity C.

There is an alternative way to show the various types of netting as portrayed in the financial accounts above in Table 1 by depicting exposures as directed graphs or “digraphs” (i.e. which limits the representation to the financial claim side only). Credit risk exposures can be framed as applications of the theory of directed graphs (“digraphs”), as reviewed by Bang–Jensen and Gutin (2007). Graph theory studies graphs, which are structures made up of nodes (“vertices”) and links (“edges”) between these nodes. An undirected graph is one in which two nodes are linked symmetrically, while directed graphs link the nodes in a directed, asymmetric way, which is represented by the links being shown as arrows, instead of lines. Networks of credit relationships are directed graphs, as links between creditors and debtors are directed. The example provided above in Table 1 can be represented in such a manner, as shown below in Figure 1.

Figure 1: Netting without and with novation in a triangular credit relationship



Numerous evolutions have taken place in an attempt to mitigate the risks of the IOU economy for the sake of lean balance sheets, lower credit risk, and better financial stability, be it through (1) bills of exchange; (2) early private deposit banks; (3) early central banks in combination with bills of exchange; or via (4) central banks acting as correspondents to private banks. In what follows, we will consider one after the other.

3. Bills of exchange in a commodity money system

3.1 Introduction

As explained above (see also McIntosh, 1988), early economic activity between merchants in local communities was largely based on an **IOU system**. As long as goodwill prevailed, settlement in precious metal coins on an amicable basis could be delayed for years. Whilst schemes based on goodwill functioned somewhat effectively, the limitations of such solutions became evident following the expansion of trade amongst strangers, particularly when economic activity began to take place across borders.⁷

As a workaround, bills of exchange began to be firstly employed as a means of remittance (up until around the 13th century), which avoided the requirement for traders to travel across jurisdictions with precious metal coins (Einzig, 1962, p. 64; see also Dean, 1884, p. 6). Narratives with respect to pinpointing the precise birth of the bill of exchange vary (see e.g. Usher, 1914; Read, 1926). Yet irrespective of their origin, a bill of exchange was an order by one entity (the “drawer”) which instructed another entity (the “payer”) to pay a third party (the “payee”) at a given date in the future.⁸ However, to overcome the drawbacks of the IOU economy, bills of exchange were used as netting instruments. Section 3.2 below will firstly describe and then depict bills of exchange as a means of remittance through a system of financial accounts, whilst section 3.3 will show how they were used as a netting instrument between (1) individual merchants and (2) banks.

3.2 Mechanics of payments

Consider a scenario where an agent proceeds to purchase a stock of goods from an exporter overseas.⁹ This would involve a “merchant bank”, which was typically a family owned international trading company (e.g. the Medici family, the Fuggers and the Rothschilds). In this case, the agent could be a merchant (i.e. a representative of the international trading company) or a private citizen. Let us proceed on the assumption that the trader pays—in their local jurisdiction and then physically travels with the bill of exchange to some other jurisdiction to buy a stock of goods. The trader, located in nation A (say in Augsburg, Germany), presents some specie (e.g. silver coins) to the local merchant bank, **Bank A**, which draws a bill of exchange on its foreign correspondent **Bank B** (in currency B, located in Florence, Italy).

⁷ It is for these reasons that we show the cross-border case in this section.

⁸ Note that bills of exchange only became “order” instruments after being accepted by the payer.

⁹ Whilst in this section we are emphasising the role of bills of exchange in cross-border payments, the principles would be identical if bills of exchange were to be employed for domestic – or “inter-regional” – payments. These came to be eventually recognised as “inland” bills of exchange (Quinn and Roberds, 2008).

Through the bill of exchange being drawn by **Bank A**, **Trader A** (the importer) becomes the payee of the bill.¹⁰ Figure 2 below shows how the stylised bill would look like. In such a scenario, an Augsburg-based agent of the payer (**Bank B**) could sign (accept) the bill. If the payer failed to pay at the due date (known as a “protest”), the payee was entitled to seek immediate compensation through a court order. Most bills of exchange were however payable at “usance”, which was the standard grace period for bills of exchange payable “on sight” (De Roover, 1948, p. 57; Bolton and Guidi-Bruscoli, 2021). For example, usance on bills drawn on Genoa and Florence was 10 and 20 days respectively. Other cities received longer grace periods, with usance for Paris and Barcelona being 2 and 3 months respectively (see e.g. Mueller, 2019, p. 295).

Figure 2: Stylised bill of exchange

Augsburg, 1.1. 1200	
Against this bill pay at sight in Florence to Trader A the sum of 100 gold ducats	
Bank B [signed - “accepted”]	Bank A [signed - “drawn”]

What could have been the economic context of such a bill? For example, Augsburg based Trader A wants to buy merchandise in Florence worth 100 gold ducats and bring the merchandise back to Augsburg. He has 500 Augsburg silver Taler which are worth 100 gold ducats, but he knows that in Florence he will have to pay to his supplier gold ducats to obtain the merchandise. Moreover, he is afraid of being robbed when crossing the alps (on the way back he will employ a security guard to protect the merchandise, but wants to save these costs on the way to Florence). He therefore takes his 500 Taler and pays them into Bank A, and then travels with the bill to Florence. In addition, Bank A sends an “Avisa” letter to Bank B in Florence with instructions that they should honor the bill.

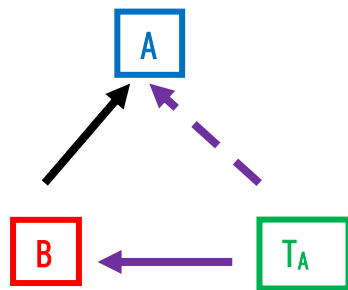
Such a scenario can also be represented in a digraph. Figure 3a captures the (post-trade) claim of Bank B on Bank A that is created as a result of bill of exchange being drawn (**black arrow**). Given that they are yet to be paid-out, the **purple arrows** represent the claim of Trader A on Bank B and also his contingent claim (dotted line) on Bank A if Bank B were not to pay. The guarantee will be transformed into a claim if Bank B does not pay. If Bank B pays, then the guarantee vanishes. Trader A travels from Germany to Italy (being happy not to

¹⁰ In this case, Bank A is the drawer, whilst Bank B as the foreign correspondent is both the payer and drawee (i.e. the entity which the bill of exchange is drawn upon).

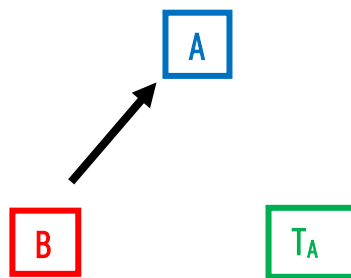
have to transport specie across the Alps) and presents the bill to Bank B, at which point they obtain a stock of gold coins at the **prevailing exchange rate “ β ”**,¹¹ and purchase a stock of merchandise. After paying out the trader, the claim of Bank B vis-à-vis Bank A remains as a residual, as shown below in Figure 3b. It is important to note that the operation **gives rise to some form of IOU structure between the two banks**. Whilst this circumvents the need to ship specie, it exposes Bank B to counterparty risk. This problem is moderated if trade flows are symmetric, in the sense that if the reverse bill of exchange operation also takes place, the claims and liabilities between the banks that result from such operations could be bilaterally netted out (possibly complemented by domestic bill netting operations - see section 3.3).

Figure 3: Digraph of claims

3.a. Drawing of bill



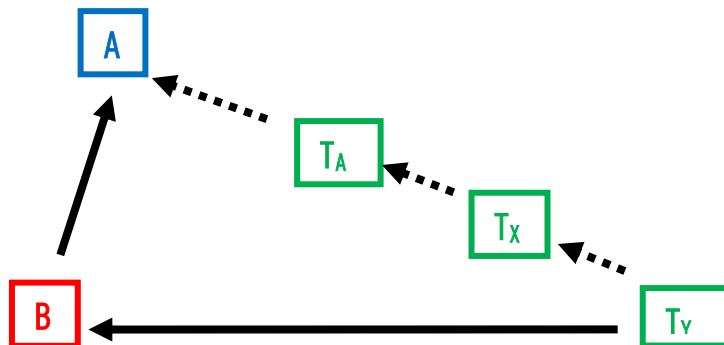
3.b. After trader is paid-out



Assume that the bill is (i) not payable “at sight” but “after 90 days”; and that (ii) Trader A already has travelled unexpectedly to Florence after 30 days and does not want to delay purchasing new merchandise (as staying unnecessarily long in Venice is costly). He can then **“endorse”** the bill of exchange and pass it on to someone else - **Trader X** - in Florence who wants to invest his cash. After 30 days, Trader X may need his money back and therefore again endorses the bill and passes it on to another holder - **Trader Y** - who holds it for the last 30 days until maturity and then cashes it in with the drawee (the payer). Note that each “endorser” (Trader A and Trader X) becomes and remains guarantor to the bill, i.e. in case the obligor or the previous endorsers all default they have pay for the bill and can then try to recover their claim towards the obligor. Before final settlement at $T+90$, the financial relationships would take the form as showed in Figure 4. After Trader Y is paid by Bank B, the same end result would apply as if the bill were not endorsed.

¹¹ From the perspective of nation A, β is the number of A-currency units required to purchase 1 B-currency unit (C_B/C_A), whilst from the point of view of nation B, the exchange rate is equal to $1/\beta$ (i.e. the number of B-currency units required to purchase 1 A-currency unit; C_A/C_B).

Figure 4: Endorsing a bill of exchange



A system of financial accounts can showcase cross-border payments via bills of exchange prior to the introduction of deposit accounts. In the case of a domestic payment, the entries in the financial accounts would be more or less identical, with the exception that (i) payments would all be in an identical currency (e.g. silver coins), and (ii) all exchange rate factors would be omitted. Consider the following steps, whereby in the financial accounts below, we portray the bills of exchange related flows as taking place simultaneous fashion (so that we omit the temporary positions relating to the drawing and redemption of the bill of exchange). We also include two trade operations, where one occurs in the reverse direction:

- Initially, Trader A pays-in via presenting a stock of silver coins to the value of " a " to Bank A.
- Trader A then travels to nation B to receive some gold coins from Bank B at the prevailing exchange rate of β (i.e. he receives βa gold coins). Note that the gold coins held by Trader A in country A are expressed in the accounts in the domestic unit of account (i.e. in silver coin value).
- Following trader A being paid out, Bank A continues to incur a cross-border interbank liability to Bank B (of value " a " silver coins) (notated a_1 in the table, the number being a time stamp, whereby $a_1 = a$).
- Trader A then purchases merchandise from trader B for a value of βa gold coins and travels back to nation B with these goods ($a_2 = a$).
- Trader B now repeats the process (albeit in reverse and not necessarily in the same amount), whereby they pay into Bank B through gold coins in the amount of " b ", travel to nation A, and then receive silver coins from Bank A of b_3/β (with $b_3 = b$).
- After paying for their imports with silver coins, Trader B returns with merchandise of value b_4/β silver coins (which equates to b gold coins) to nation B (with $b_4 = b$).

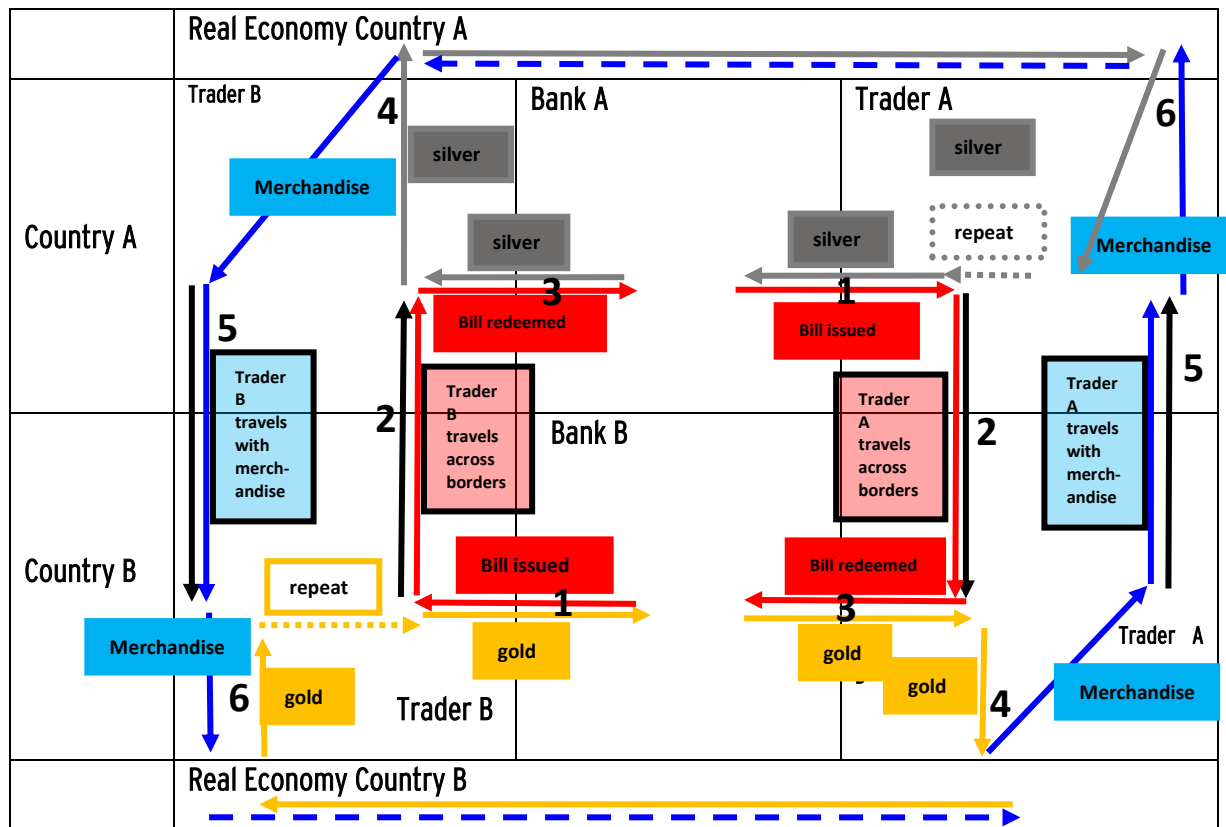
Table 2: Payments via bills of exchange in a commodity money standard

Country A - Accounts in silver coins			
Trader A			
Real goods	X	+ a2 - b4/β	Capital X
Gold coins	X + a1 - a2		
Silver coins	X - a1	+ b4/β	
Bank A			
Specie	X + a1 - b3/β	Liability to Bank B	X + a1 - b3/β
		Capital	X
Country B - Accounts in gold coins			
Bank B			
Specie	X - βa1 + b3	Capital	X
Claim on Bank A	X + βa1 - b3		
Trader B			
Real goods	X - βa2	+ b4	Capital X
Silver coins	X	+ b3 - b4	
Gold coins	X + βa2 - b3		

return to their initial value. This constitutes a case of a trade (and payments) balance in equilibrium. Figure 5 below illustrates the case of cross-border payments prior to the introduction of deposit banks in a commodity money standard.¹² The arrows in Figure 5 do not represent claims and liabilities, but movements of merchandise, precious metal, financial documents, or people between trading centers. After paying into the bank in specie (step 1), it is assumed that each bank draws a bill of exchange on their correspondent, and that traders travel across the border (step 2), upon which they receive local currency at the prevailing exchange rate β through being paid-out in specie (step 3). Traders then purchase some merchandise (step 4), and travel back to their home country (step 5) to sell their newly acquired goods (step 6), etc. We adopt the following color coding: red relates to the bill of exchange, gold and silver relate to precious metal coins, black relates to the physical travel of the trader, and blue relates to merchandise.

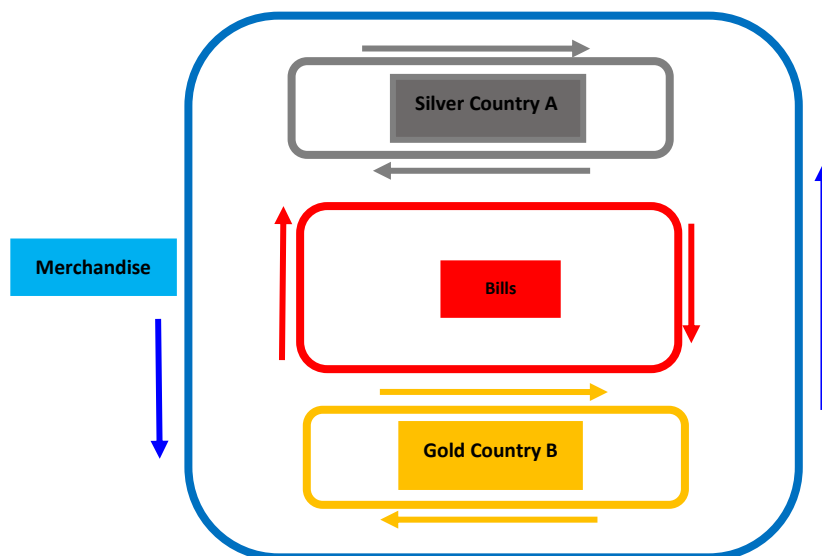
¹² Although in this case we describe a cross-border payment, the process for executing a domestic payment would be very similar.

Figure 5: Circular economic flows in a commodity money standard



The circular economic flows are shown in a more stylized way below in Figure 6:

Figure 6: Stylized circular economic flows



The financial flow cycle in the middle (in red) allows the specie flow cycles to be separated into two distinct parts, which avoids the costs and risks of shipping specie. Furthermore, note that the merchandise circle (in blue) is somewhat different from the specie flow circles in the sense that these are real goods and are in permanent transformation. Finally, the bill circle is again of a particular nature, since bills of exchange are issued, redeemed, and then re-issued etc.

3.3. Decentralised netting through bills of exchange

In the section above, we discussed the case of an equilibrated balance of payments with just two traders and two banks. Yet in reality, there was a variety of traders and banking houses that operated cross border signifying that netting was more complex, i.e. IOUs between banks did not simply disappear through trivial bilateral netting. However, bills of exchange were also used as decentralised netting mechanism for IOU networks involving various parties, and can be traced back to the late Middle Ages, where post-trade claims and liabilities **between traders (i.e. merchants)** were netted at trade fairs (Colwell, 1859, chapter 12; see also Giovanoli, 1997; Börner and Hatfield, 2017). According to Kindleberger (1984, p. 36):

"Settlement involved a species of clearing. Each merchant kept a book in which he entered what he owed... and what was owed to him... When the date for settlement came, an official at the fair would validate the claims and liabilities in the merchant's book, and effect cancellations to reduce the need for payment in coin."

In later years, bills of exchange also acted as a decentralised netting instrument for the netting of **interbank post-trade claims**. Kohn (1999a, p. 21) depicts how interbank post-trade claims and liabilities were netted through bills of exchange during the Lyon fairs in the 15th and 16th century (see also Andrews, 1942; Desan, 2014, p. 228; Giovanoli, 1997, p. 521):

"Some markets...were...'inside markets'¹³. In these markets, merchant bankers traded principally with one another... At Lyons, at the beginning of each fair - on a date set at the previous fair - the merchant bankers convened at the lodge of the Florentines. Each had prepared in advance a 'market book' listing his receivables (outstanding bills on which he was the payee) and his payables (outstanding bills on which he was the payer). During the meeting, the bankers compared their books...Equipped with their market books, pairs of merchants would net payments due to one another bilaterally. Any remaining imbalance...might be netted...by drawing new bills payable at the next fair or at other banking places. By the end of this process, very little remained to be settled in cash..."

Felloni (2012, p. 22) also describes this phenomenon:

"Bills of exchange were initially domiciled in trade fairs held in the Champagne area of France and subsequently in Geneva, Lyons and Antwerp... The exchange fairs [in Genoa] lasted eight days and were held four times a year at

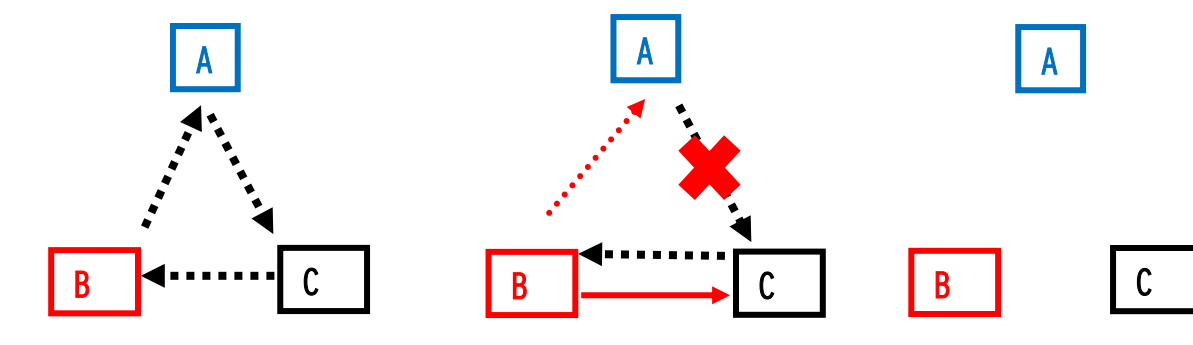
¹³ Today, "inside markets" would be recognised as "wholesale markets".

regular intervals... The primary players in these transactions were bankers, merchants or agents, who moved from their home markets to the fairs in order to settle their firms' bills or those of others. The fairs utilized their own monetary system based on a unit of account (the scudo) that was fixed to gold. In this way, the fairs acted as a form of suction pump that would attract bills from all over Europe, settle them with a multiple clearing system that was a forerunner of today's clearing houses, and issue new bills for use on individual trading markets or later exchange fairs..."

Depending on the circumstances, netting could involve a bill of exchange being endorsed multiple times (Colwell, 1859, pp. 280–287). To this end, Van der Wee (2013, p. 342) remarks that "...one gets the impression that a given commercial debt was transferred so often that finally somebody was found who happened to be a debtor of the original debtor, which enabled a full or partial clearing of debts." To depict the multilateral netting of post-trade claims between three entities, consider a triangular credit circle between three merchant banks, such as that in Figure 7a.¹⁴ Initially, Bank A should draw a unit-value bill on Bank C (payer) with Bank B as payee (i.e. Bank C must pay Bank B). Bank C accepts (i.e. signs the bill and accepts the order to pay) against a unit payment, which eliminates the claim of Bank A vis-à-vis Bank C (**red cross**). To eliminate their liability to Bank B, the drawer of the bill (Bank A) transfers the ownership of the original bill to Bank B. The created claim is shown by the **red line**, and the guarantee is shown as a **dotted red line**, being a contingent claim of Bank B on Bank A. Bank B and Bank C can now net their bilateral claims (as depicted above), and the guarantee issued by Bank A is terminated. In this way, bills of exchange were able to net away a level of post-trade credit-interconnectedness in a decentralised fashion, which avoided (1) redundancies in balance sheets and (2) the constant shipping of specie. However, **decentralised multilateral netting is only permissible in the presence of a credit circle.**

Figure 7: Netting a credit circle of post-trade claims with one bill of exchange

7.a. The initial credit circle 7.b. After BOE issued 7.c. Post BOE settlement



¹⁴ For a more complex example, see the Annex.

4. Early private deposit banks in a convertible financial money system

4.1 Introduction

Although bills of exchange minimised the requirement for traders to travel with specie, **payment through coins were inconvenient, costly and time consuming**. As Dean (1884, p. 25) puts it, “[s]uch was the great diversity of coinage in Europe that the custom of settling all mercantile transactions in the currency of place became well-nigh universal. Not only would sellers have refused to accept money whose value was unknown to them, but in many places they were forbidden to do so by law.” It became therefore necessary to pay a professional “moneychanger” to ensure that the type and quality of any coins tendered were of the required standard (Einzig, 1962, pp. 61–63; Mueller, 2019, chapter 1). Indeed, not only were the various types of coins an issue, but also the heterogeneity within every type of coin, due to imperfect production, usage or manipulation. Moreover, whilst coins in some cases proved to be inadequate in enabling very small-value transactions, payment in coins for high-value transactions was cumbersome as it required (in principle) every coin to be examined (Desan, 2014, p. 112).

To sidestep the inconveniences and constraints of traders executing transactions in specie, **early deposit banks - and hence financial money - came into being by around the 12th century in Italy** (Usher, 1934; De Roover, 1948, p. 247; see also Bindseil, 2019a and references therein). However, given the perceived importance of specie as the ultimate unit of account, deposits remained convertible into precious metal. Section 4.2 below will show the mechanics of payments through bills of exchange and early deposit banking via a system of financial accounts, while section 4.3 will describe the drawbacks of the IOU economy with early deposit banking.

4.2 Mechanics of Payments

The advent of early deposit banks led to several innovations. First, it was now possible for traders to execute both domestic and cross-border payments to one another by book-entry - or via “assignment” or “giro transfer” - as opposed to transfers of specie (Lane, 1937). This relied on both the payer and payee having a deposit account at the same bank.¹⁵ Through book-entry, payers would instruct the bank to shift a proportion of their deposits to the payee via a transfer of ownership, and the “debts” of the bank (i.e. deposits) would be reassigned. Typically, such an order would be given orally by the payer or via an intermediary. Hence as

¹⁵ In some cases, traders held accounts in several banks, both within their home jurisdiction and in banks across borders. Also, it was common for many banks to allow their depositors to incur overdrafts (De Roover, 1948, pp. 272–294).

opposed to a bank paying out specie, the bank would reregister the ownership of specie from the payer to the payee - known as "payment in-bank" (Usher, 1934).

Second, the advent of deposit accounts and payment in-bank created the pre-condition for private deposit banks to become central clearance counterparties to traders. Now post-trade claims and liabilities between traders could be netted and any residual settled with **novation**, with net claims resulting in a trader increasing their deposits at a bank. Efficiency gains were particularly obvious in the case where many bills of exchange had the same settlement date (such as a certain day per quarter). Although in some instances the payee could choose to be paid-out in specie, the majority of traders opted for payment in-bank and hence accepted the novation of claims, as highlighted by De Roover (1948, p. 57):¹⁶

"It would be a mistake to believe that bills were usually paid in specie. The records of the Datini branch in Barcelona disclose that such was not the case and that bills of exchange were often paid by assignment in bank...For example, a bill drawn by the Orlandini of Bruges on the Datini branch in Barcelona was accepted by the drawee on August 30, 1398, and paid by assignment in bank, that is, by transfer in the books of the money-changer on October 1, 1398."

Kohn (1999a, p. 21) also makes similar conclusions:

"[In] [p]ublic markets, where merchant banks offered their services to the general merchant public normally relied on payment in bank...In a public market, where most trade took place among strangers, deposit banks provided a means of settlement that everyone could trust. Such a system could be incredibly efficient: for example, between 1456 and 1459, one bank in Genoa received 160.000 lire in payments from abroad in bills of exchange, and only 7.5% of this amount was settled in cash [i.e. paid-out in specie]: the remaining 92.5% was settled in bank."

Third - to complement existing correspondent relationships with other banks for both domestic and cross-border payments - banking houses began to proliferate throughout Europe via the opening of branches (Usher, 1914). A prime example was the Italian Medici Bank (see e.g. De Roover, 1963, chapter 5). As portrayed by Kindleberger (1984, p. 43), by the start of the 15th century "[i]t had branches in Venice, Genoa, Milan and Rome, as well as a head office in Florence...and outside representation in London, Bruges, Geneva...plus a correspondent in Lübeck." Similarly, De Roover (1944, p. 384) denotes that although the merchant banker Francesco Datini established his headquarters in Prato, his firm was equipped with branches in "...Florence, Pisa, Genoa, Avignon, Barcelon, Valencia, and Majorca."

Finally, banks by the mid-14th century began to hold reciprocal deposits with one another within "nostro" accounts ("our account with you") at correspondent banks. From the perspective of the correspondent bank,

¹⁶ One explanation for this could have been that during the early stages of deposit banking, deposits could only be withdrawn for specie on demand during trade fairs (Kohn, 1999b).

the identical account was recognised as a “vostro” account (“your account with us”) (see e.g. Usher, 1943, p. 20; De Roover, 1944). To accrue deposits with one another, both banks would credit the vostro account of the respective other bank. Whilst banks still maintained an IOU structure after executing payments on behalf of traders via bills of exchange, a settlement of claims would involve the creditor bank debiting the vostro account of the respondent bank (as opposed to shipments of specie). Nonetheless, settlement only occurred at irregular intervals (De Roover, 1948, p. 272).

We can portray the execution of payments via deposit banking in a system of financial accounts, whereby the bank of the payer draws a bill of exchange on its correspondent. In this example of a cross-border payment,¹⁷ we assume that as opposed to travelling to purchase goods, payers are equipped with agents that act on their behalf (see e.g. Usher, 1914; De Roover, 1963, p. 138). Further, we presume that as opposed to traders travelling with bills of exchange, the bank sends the bill to its correspondent via the mail (see e.g. Mueller, 2019, p. 295 for a list of postal times). Finally, we proceed on the proviso that both the payer and payee have accounts at the same bank, and that all transactions happen more or less simultaneously. Consider the following steps:

- In proceeding to purchase a stock of goods from Trader B, Bank A debits the deposit account of Trader A in the value of “ βa ” (where β is the amount of silver coins required to purchase 1 gold coin), and draws a bill of exchange on Bank B.
- Rather than paying-out trader B in specie, Bank B debits (credits) the deposit account of Trader A (Trader B). Note that in the financial accounts, the net result is shown.
- Trader A then receives a stock of goods ($a1$).
- **The process is now repeated (albeit in reverse and not necessarily in the same amount)**, in the amount of “ b ”.
- After the deposit account of Trader A is credited, Trader B receives a stock of goods ($b1$).

¹⁷ Once again, if it were to be a domestic payment, (1) all entries in the accounts would be in an identical currency, and (2) the exchange rate factors would not be included.

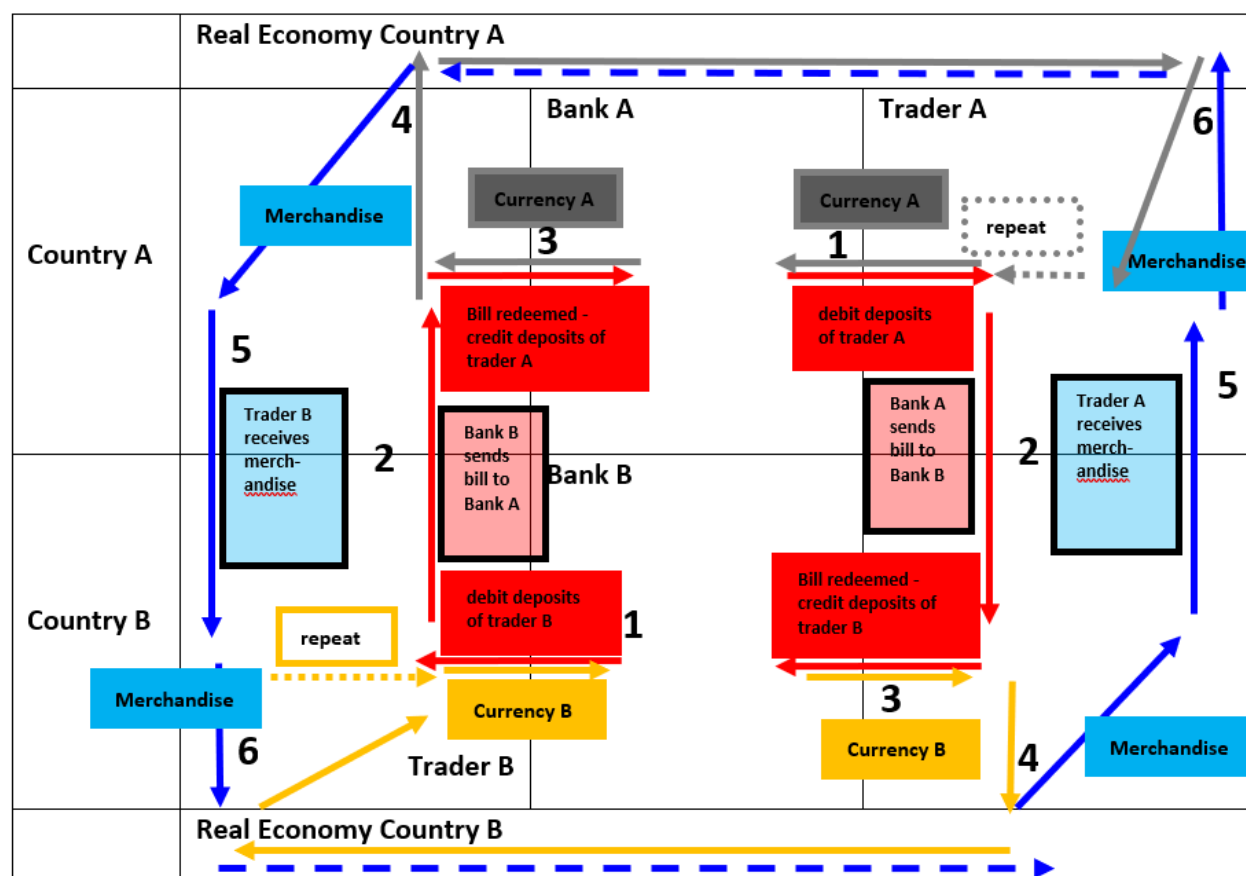
Table 3: Payments via bills of exchange in a convertible financial money standard

Country A - Accounts in silver coins			
Trader A			
Real goods	X $+\beta a1$	Capital	X
Deposits	X $-\beta a1 + b1$		
Bank A			
Specie	X	Deposits	X $-\beta a1 + b1$
Nostro A	X	Liability to Bank B	X $+\beta a1 - b1$
		Vostro B	X
		Capital	X
Country B - Accounts in gold coins			
Bank B			
Specie	X	Deposits	X $+a1 - b1/\beta$
Claim on Bank A	X $+a1 - b1/\beta$	Vostro A	X
Nostro B	X	Capital	X
Trader B			
Real goods	X $-a1 + b1/\beta$	Capital	X
Deposits	X $+a1 - b1/\beta$		

Figure 8 depicts the correspondent payments flows between banks on behalf of their respective traders in a convertible financial money standard, analogous to the case where the domestic circular economies use species as means of payment (Figure 5). In this portrayal of a cross-border payment,¹⁸ the bank of the importer debits the deposit account of the trader, and sends the bill of exchange to its correspondent in the mail (steps 1 and 2). After receiving and accepting the bill, the bank of the exporter then credits the deposit account of the respective trader (step 3), which allows the purchased goods to be received (steps 4, 5 and 6).

¹⁸ Again, the process of a domestic payment would be very similar.

Figure 8: Circular economic flows in a convertible financial money standard



4.3. The drawbacks of early deposit banking

Although there were distinct efficiency gains with early private deposit banking, **traders were highly conscious of counterparty credit risks**. As a direct consequence, bank runs and failures were frequent (Kohn, 1999b).¹⁹ With the absence of a credible lender of last resort, local legislators imposed a raft of regulations. Typically, these ranged from the imposition of liquidity buffers (in the form of reserve ratios) to capital requirements where assets could be seized in the event of failure (Roberds and Velde, 2016). In the face of protracted runs however, banks were forced to suspend convertibility. This was generally done by banks prohibiting the withdrawal of deposits in specie whilst at the same time allowing traders to continue to execute payments in-bank. In other instances, the authorities simply banned deposit banking altogether. For example, Kohn (2001)

¹⁹ Even outside of periods of extreme market stress, the reserves of banks (i.e. stocks of specie) ebbed and flowed. De Roover (1948, pp. 237–238) notes that in Bruges, the reserve ratios of banks typically fell during the new year period as traders withdrew specie to purchase winter clothing in other trading districts.

refers to the case of the Burgundian Low Countries, where in 1489, payments were banned from being executed in-bank. This then led to the complete disappearance of deposit banking in the Low Countries by the end of the century.

Creditor banks also remained highly exposed to counterparty credit risk, as the failure of debtor banks would result in a direct loss on their books (Norman, Shaw and Speight, 2011). As a result, many banks only accumulated claims on entities within their respective banking groups (as opposed to maintaining some sort of IOU structure with other banks). Generally, this was done through the use of bank drafts (De Roover, 1963, p. 13). As Usher (1914, pp. 571–572) puts it:²⁰

“The elaborate notarial form was no longer necessary, a simple letter of member of the firm was sufficient to create an obligation on the other establishments...the transaction gave rise to three records: a book entry of the sum received by the member of the firm issuing the draft; a paper given [to] the creditor of the firm acknowledging the obligation and mentioning the place where it was to be discharged; finally, a letter, called the ‘Avisa’ letter, sent from the branch drawing the draft to the branch which was required to pay the money.”

Nonetheless, the drawbacks of such a scheme were that large deposit banking groups were able to gain significant oligopolistic or (in the extreme) monopolistic power (see e.g. Fratianni and Spinelli, 2006). In the interests of financial stability, and to avert the complete monopoly of banking through private entities, many argued for the creation of a **public deposit bank**. As outlined by Roberds and Velde (2014, pp. 18–19) in the context of Venetian banking before the establishment of a public deposit bank, i.e. before 1587:

“The Senator Tommaso Contarini made a long speech arguing for the establishment of a public bank...He explained that trade needed a system of payments; he described the fairs of Lyon and the settlement mechanism [through bills of exchange] of Antwerp, but argued that those systems, relying on private trust...was unsuitable in Venice with its multitude of merchants of different nationalities and creed... Bank transfers had proven indispensable, but experience showed that private banks could not be relied upon in the long run, and he cited the figure of 96 failed banks in the history of Venice. The incentives for over-issue of credit were too strong, and Contarini also blamed bankers for the variability in exchange rates between coins. Only a state-sponsored entity could provide the service, and Venice had the advantage of an infinitely-lived and trustworthy government.”

The subsequently established Banco di Rialto (1587–1638), and later on the Banco del Giro (1619–1800), would provide to Venice in the subsequent 300 years a means to settle in public Giro money, improving the situation considerably relative to the case of exclusive reliance on private deposit banking operating amongst themselves as a network of correspondent banks and only occasionally settling in species (gold ducats).

²⁰ Strictly speaking, this is in the context of intra-banking group payments in a system of commodity money. Nonetheless, the process in a system of financial money would be more or less identical (see also Usher, 1943, p. 81).

5. Bills of exchange and early central banks in a convertible financial money system

5.1. Introduction

In a bid to maintain the efficiencies of trade and commerce with deposit banking, **early public deposit banks (i.e. central banks) were established as of the 15th century**. Reviews of early central banking can be found in Roberds and Velde (2014, 2016) or Bindseil (2019a) (see also references therein).²¹ Although the arrangements of early public deposit banks differed, specie as a basis for the financial system was still considered the superior alternative to non-convertible money. Thus as with private deposit banks, convertibility necessitated the authorities to hold assets in either specie or other highly liquid assets, which when required, could readily be converted into precious metal in one way or another (see e.g. Bindseil, 2019a, pp. 40–43).

In tandem with holding convertible deposits on behalf of traders, **early public banks began to issue notes by the 17th century that were also redeemable into specie**. It is widely supposed that the first to do so was the Stockholms Banco in 1661. Such operations ended in 1664 after the bank was unable to redeem its notes into specie and was succeeded by the Swedish Riksbank in 1668. However, after heeding the lessons from the Stockholms Banco, the Riksbank was prohibited from initially issuing notes (Roberds and Velde, 2014; Bindseil 2019a, p. 72).

From the 15th to the 20th century, central banks and bills of exchange formed a symbiosis which permitted further improvements with respect to the security and efficiency of domestic and cross-border payments. Moreover, the netting of post-trade claims became much easier than under decentralised mechanisms. In what follows, section 5.2 will present the netting technique that predominated from the 15th to the 18th century, while section 5.3 explains the technique that became more or less standard from the 18th to the middle of the 20th century.

5.2. Obligatory settlement of bills of exchange in central bank money

In 1446, the city of Barcelona declared it mandatory to settle bills of exchange beyond a certain size in central bank deposits at the Taula de Canvi (Ugolini, 2016, p. 48). This was also introduced by the Venetian authorities with respect to settling bills of exchange at the Banco di Rialto in 1593 (Dunbar, 1892). Analogously, following the foundation of the Bank of Amsterdam in 1609, the city decreed that bills of

²¹ The advent of early central banks did not necessarily result in the complete elimination of private deposit banks (see section 6).

exchange of more than 600 florins were to be settled in the books of the bank. As noted in paragraph 4 of the mandate of the Hamburger Bank of 22 February 1619 (see Bindseil, 2019b, section 3.2):

"Accordingly, the Council of the City hereby orders and reminds all citizens, inhabitants and subjects and everyone that after this, all bills of exchange payable here [in Hamburg], maturing after this date, if the sum is 400 Mark Luebisch or more, are to be registered and paid in the said Banco, with the warning that, in case of non-obedience, each time bills of exchange are settled outside the Banco, 25 Mark are to be paid to the Banco, and will be requested by the masters who have been tasked to do so."

Similarly, the regulations of the Royal Bank in Berlin and Breslau of 29 October 1766 stated that (see Bindseil, 2019b, section 7.3):

"All foreign bills and payment orders which import at least 100 Reichstaler have to be denominated (by order of the domestic merchant) in Banco-Pounds, be accepted and settled in Banco Pounds through the banks. If such bills or payment orders are not denominated in Banco-Pounds, then still the drawee must not accept payment different than in Banco-Pounds."

Through the obligatory settlement of bills in central bank money, the decentralised mechanism of **traders netting post-trade claims and liabilities through drawing and endorsing bills of exchange** (as described above in section 3.3) was superseded. This was also superior to **private banks acting as central clearance counterparties** (as described in section 4.2), as following the settlement of any residual post-trade claims, traders accrued deposits in convertible central bank money (as opposed to convertible commercial bank money). In describing the operations of the Banco Di Rialto, consider some remarks by Dunbar (1892, pp. 322–323), who describes how decentralised netting via bills of exchange was outlawed:

"There has been introduced within a short time a notable abuse in the Piazza di Rialto: that payments...are made by a kind of transfer in which debtors assign to their creditors each one his debtor, and this debtor assigns another, and so on...This transfer...of debts, when cash was really due, was therefore forbidden; and a few days later the act of December 14, 1593, after a similar recital of the evil, made the well-known requirement for payment in-bank of all bills of exchange, under severe penalty...This led to a practice of settling bills of exchange by novation, or the substitution of one debtor for another..."

The settlement of bills of exchange in central bank money remained the standard in cities endowed with public banks, until a large proportion of these banks failed with the advent of the Napoleonic wars due to the constraints imposed by maintaining convertibility into precious metals (Roberds and Velde, 2016). To bypass the limitations of convertibility, some public banks (e.g. Bank of England) resorted to suspending convertibility, albeit on a temporary basis. Moreover, many early public banks became susceptible to abuse due to the fiscal demands of the state (Roberds and Velde, 2014; Bindseil, 2019a, pp. 89–93).

5.3. Discounting bills of exchange by central banks

During the course of the 18th century, a number of central banks developed another method to facilitate the netting of post-trade claims on a centralised basis with novation. Under such a technique, **central banks “discounted” (i.e. purchased) bills of exchange before maturity and then held them as an asset until the payment date.** Indeed up to around the beginning of the second half of the 20th century, discounted bills of exchange remained a key asset class of central banks (Jobst and Ugolini, 2014).

The Bank of England’s Vice-Governor Godfrey refers in 1695 to the discounting of bills of exchange by the Bank of England during its second year of operations:

“Foreign bills of exchange are discounted at 4.5% per annum, and inland bills and notes for debt at 6% per annum, and those who keep the cash in the Bank, have the one discounted at 3% per annum and the other at 4.5% per annum for which most Goldsmiths used to take 9 or 10% per annum.”

Similarly, the regulation of 10 May 1699 of Leipzig Banco (Bindseil, 2019b, section 5.3), Title IX, Article 3 specifies that:

“To make sure that the merchants will be helped even more by this Banco, one has found good that merchants can also obtain money without collateral but on bills of exchange, if such a letter has been endorsed by one further merchant, and if the borrowing merchant owns unpledged land property within the country.”

To depict how the discounting of bills of exchange by central banks acted as a centralised netting with novation mechanism, consider the following steps below which depicts the process in the cross-border context (where again we assume that traders have agents in the other jurisdiction):

- Suppose that after drawing a bill of exchange on Bank B in the amount of “**a**” (which from the perspective of nation A is equal to “**βa**”), Bank A debits the deposit account of Trader A, and incurs an interbank liability to Bank B. Trader A now has a claim on Bank B (**a1**).
- **Prior to the bill maturing, central bank B purchases the bill of exchange from Trader A,** and as a result, Trader A receives a stock of banknotes from central bank B. Thus, the post-trade claim of Trader A vis-à-vis Bank B has been novated in the sense that now Trader A has a claim on central bank B through acquiring a stock of banknotes (i.e. central bank money). Also, central bank B now has a claim on Bank B (**a2**).
- With their banknotes, Trader A purchases a stock of goods from Trader B (**a3**).
- At the next occasion, Trader B pays the cash into their account with Bank B. On the evening of the same date, Bank B pays the cash into their deposit account with central bank B (**a4**).
- At the maturity of the bill, central bank B debits the deposit account of Bank B (**a5**).

Table 4: Discounting a bill of exchange by the central bank

Country A – Accounts in currency A					
Trader A					
Real goods	X	$+\beta a3$	Capital	X	
Deposits at Bank A	X	$-\beta a1$			
Claim on Bank B	X	$+\beta a1 - \beta a2$			
Banknotes	X	$+\beta a2 - \beta a3$			
Bank A					
Specie	X		Deposits trader A	X	$-\beta a1$
			Liability to Bank B	X	$+\beta a1$
			Liability to central bank B	X	
			Capital	X	
Country B – Accounts in currency B					
Bank B					
Claim on Bank A	X	$+a1$	Deposits	X	$+a4$
Deposits at central bank	X	$+a4 - a5$	Liability to trader A	X	$+a1 - a2$
Specie	X		Liability to central bank B	X	$+a2 - a5$
			Capital	X	
Central Bank B					
Claim on Bank B	X	$+a2 - a5$	Deposits of banks	X	$+a4 - a5$
Specie	X		Banknotes	X	$+a2 - a4$
Other assets	X		Capital	X	
Trader B					
Real goods	X	$-a3$	Capital	X	
Banknotes	X	$+a3 - a4$			
Deposits at Bank B	X	$+a4$			

6. Central banks as correspondents in a financial money system

6.1. Introduction

Thus far, this paper has surveyed numerous evolutions in (1) the formation of IOU networks as a means to overcome settlement in specie, and (2) the process by which financial stability risks have been mitigated through netting post-trade claims without and with novation. In this section, the final evolution of netting post-trade claims and liabilities will be shown, whereby **central banks act as correspondents to private domestic banks (be it in a convertible or non-convertible financial money system)**. In doing so, it will be argued that in tandem with minimising the drawbacks of the IOU economy to the largest extent, **such a solution also ensures that the financial system remains layered**. Section 6.2 will describe the case of domestic payments, whilst section 6.3 will outline the case of cross-border payments.

6.2. Central banks as correspondents in domestic payments

It can be proposed that the first central bank – the Taula de Canvi in Barcelona, established in 1401 – shared many operational characteristics with those of its contemporaries in that **it acted as a correspondent to the domestic banking system**, given that private banks held their reserves on its books (Usher, 1948, p. 185). This also allowed traders to complete payments to one another even where the payer had a deposit account at a different bank to that of the payee (De Roover, 1948, p. 272). As a central clearance counterparty, the Taula's books were taken by its representatives to the local trade fairs. Interbank payments were then settled across the books of the Taula, with the result being that creditor banks increased their deposits at the central bank.²²

Indeed, it is only through central banks acting as correspondents to the private banking system that the difficulties synonymous with the IOU economy are able to be averted to the largest degree. **From the point of view of banks:** interbank post-trade claims are netted with novation on a centralised multilateral basis, with any residual claims resulting in creditor banks accumulating deposits at the central bank. Given that such a construct results in the accumulation of risk-free IOUs, the need for banks to maintain some form of IOU structure between themselves is avoided. **From the perspective of traders:** they accrue deposits in commercial bank money, which are in turn buttressed by central bank money in the form of reserves. Deposits are also readily convertible into central bank money through the provision of banknotes.

It is in this sense that central bank money forms the base to the "IOU pyramid", and through its issue, is an efficient solution to overcome the drawbacks of the IOU economy. In the words of Aglietta and Mojon (2010, p. 235):

"Because bank money is a debt, it is the counterpart of credit. Because debts must be settled in other forms of debts, there is a hierarchy of debts and for that matter of the institutions that issue them. The central bank is the bank that issues the debt in which all other debts are settled. The hierarchy of the banking system, whereby the central bank issues the high-powered money that can be used for the settlement of interbank debts, appeared as a necessary condition for the integrity of the system of payments."

In a similar fashion, consider some remarks from CPSS (2003, pp. 9–13):

"The smooth and safe functioning of a payment system is dependent not just on the quantity of the settlement asset. It also depends crucially on the quality of the asset and thus on the identity of the settlement institution...Settlement

²² The ability of traders to hold their deposits at both the Taula and at private banks did however culminate in tensions developing between the City and the private banking system. Given the mitigation of counterparty risks through settlement at the Taula, the City eventually prohibited private banks from holding deposits at the bank in 1437 (Ugolini, 2016, p. 47).

takes place in the settlement institution's liabilities, and both paying and receiving banks need accounts with that institution. Both are reliant on the settlement institution's operational soundness. And they will be exposed to credit risk on the settlement institution in relation to any funds held on account...The use of central bank money as the settlement asset in systemically important payment systems... [It]...eliminates credit and liquidity risk at the apex of the payment system, where exposures are generally highest and most concentrated, and where direct participants have least choice over the source of their exposure. And the central bank's role as settlement institution provides assurance of continuity in the provision of liquidity and in the provision of settlement services...Indeed, the term 'ultimate settlement' has sometimes been used to indicate settlement in central bank money."

On the basis that central bank money carries no risks to end users, an important question to consider is why all agents in the economy cannot simply have an account with the central bank?²³ The **"layering" of the financial system** relates to a number of issues:

- (i) Loss of efficiency due to large dominant firms and monopolies. Therefore, it is prudent to limit the activities of the firms providing central functions to what is really the core of the central function.
- (ii) Credit and fraud risk management requires detailed knowledge of players and ecosystems, and a firm providing a central function should avoid being directly exposed to a very large set of heterogeneous participants or counterparties.
- (iii) Intermediaries may be able to offer connectivity to clients which is tailor-made and more convenient.
- (iv) Synergies at the local level: the local intermediary has local expertise on customer relationships from the perspective of deposit taking, payments and lending. Integrating such know-how into a single monolithic bank or infrastructure would be inefficient.

CPSS (2003, pp. 1–2) provide the following rationale with respect to the logic of layering:

"...the composite of central and commercial bank money is an essential feature of the monetary system and should be preserved. A multiplicity of issuers of money preserves the advantages of competition in providing innovative and efficient means of payment and, indeed, in providing financial services generally. The regulated or licensed character of these issuers (commercial banks) aims at promoting their solvency and liquidity in order to preserve confidence in the currency. And the use of central bank money in payment systems puts the value of banks' liabilities to the test every day by checking their convertibility into the defined unit of value. This policy position implies a rejection of the two extreme arrangements of monobanking, where the central bank acts as the sole issuer of money, and free banking, where commercial banks provide all the money required by the economy. Neither of these corner solutions has proven to be sufficiently stable or efficient to endure."

²³ This question applies to how central bank digital currencies should be issued (see e.g. Bindseil, 2020; Bindseil, Panetta and Terol, 2021 and references therein).

Therefore, the financial and payments architecture always has to strike a balance between being parsimonious and aiming at the leanest balance sheets (and hence the fewest number of creditor/debtor relations), while on the other hand allowing for useful specialization and layering.

6.3. Central banks as correspondents in cross-border payments

As explained by Einzig (1962, p. 179), during the 19th century cross-border payments began to be increasingly executed without recourse to bills of exchange:²⁴

"Banks in the leading Foreign Exchange centres gradually acquired the habit of keeping permanent balances with each other for the requirements of their Foreign Exchange business. They came to trust each other sufficiently to accept informal transfers from such balances as a basis of Foreign Exchange transactions, and to grant each other overdraft facilities in their own currencies, instead of insisting on receiving bills of exchange from the borrower... The first transatlantic cable was completed in 1866, and it is reasonable to assume that from the very outset banks on both sides of the Atlantic made much use of it for transfers"

We can consider a system of financial accounts to depict how the financial system is augmented through central banks acting as correspondents in the case of cross-border payments. Consider the following steps, where we again assume that all payments occur more or less simultaneously:

- In ordering a stock of goods from Trader B in the amount of **"a"** (which, from the perspective of country A, is equal to **"βa"**), Bank A1 debits the deposit account of Trader A.
- Since it is a small bank, Bank A1 relies on the services of Bank A2 to execute any cross-border payments. Hence, Bank A1 shifts reserves to Bank A2 via the RTGS system.
- Bank B2 then debits the vostro account of Bank A2, and moves reserves to the bank of the payee (i.e. Bank B1).
- Bank B1 then credits the deposit account of Trader B for the amount.
- **The process is now repeated (albeit in reverse and not necessarily in the same amount), in the amount of **"b"**.**

²⁴ This is not to say that cross-border payments were not executed on a wide-scale through bills of exchange. Indeed, cross-border payments continued to be facilitated through bills of exchange until the middle of the 20th century.

Table 5: Payments in a convertible or non-convertible financial money system

Country A - Accounts in currency A			
Trader A			
Real goods	$X + \beta a - b$	Capital	X
Deposits with A1	$X - \beta a + b$		
Bank A1			
Deposits at central bank	$X - \beta a + b$	Deposits	$X - \beta a + b$
Other assets	X	Capital	X
Bank A2			
Deposits at central bank	$X + \beta a - b$	Deposits	X
Nostro A2	$X - \beta a$	Vostro B2	X -b
Other assets	X	Capital	X
Central Bank A			
Other assets	X	Deposits Bank A1	$X - \beta a + b$
		Deposits Bank A2	$X + \beta a - b$
		Banknotes	X
Country B - Accounts in currency B			
Central Bank B			
Other assets	X	Deposits Bank B1	$X + a - b/\beta$
		Deposits Bank B2	$X - a + b/\beta$
		Banknotes	X
Bank B2			
Deposits at central bank	$X - a + b/\beta$	Deposits	X
Nostro B2	X -b/ β	Vostro A1	X -a
Other assets	X	Capital	X
Bank B1			
Deposits at central bank	$X + a - b/\beta$	Deposits	$X + a - b/\beta$
Other assets	X	Capital	X
Trader B			
Real goods	X -a +b/ β	Capital	X
Deposits with B1	$X + a - b/\beta$		

We can observe that the advantages associated with central banks acting as correspondents continue to apply. That is to say, domestic interbank post-trade claims and liabilities continue to be netted on a centralised multilateral basis with novation, with any residual claims resulting in banks accumulating deposits at the central bank (i.e. risk-free IOUs), which averts the need for banks to maintain any form of IOU structure between themselves. Second, traders continue to accumulate deposits in commercial bank money, which is (i) backed by central bank money, and (ii) is also readily convertible into central bank money through the provision of banknotes.

One notable differential between domestic and cross-border payment frameworks is that settlement in central bank money for any cross-border payment leg is currently not possible (see e.g. Bindseil and Pantelopoulou, 2022 for some novel solutions). This is why the notion of correspondent banking makes sense for cross-border payments, but not for domestic payments.

7. Conclusion

Given the inefficiencies and risks of the IOU economy, this paper has reviewed the evolution of clearing, netting and settlement mechanisms that have been developed as means to overcome these drawbacks. This paper has reviewed several such evolutions through (1) bills of exchange, (2) early deposit banks, (3) central banks in combination with bills of exchange, or via (4) central banks acting as correspondents. In tandem, this paper also outlined how financial instruments (such as bills of exchange), private deposit banks and central banks have been crucial in facilitating domestic and international trade.

In describing the solutions through systems of financial accounts, it was shown that although netting without and with novation is a powerful means to reduce credit risk and financial instability risks, it has only been through central banks acting as correspondents to private domestic banks that the drawbacks of the IOU economy have been alleviated to the greatest extent. Through the reliance on settlement in central bank money and through holding a central liquidity account with the central bank, banks concentrate their financial liquidity in the form of risk-free and highly efficient (since fully fungible) money. Moreover, the need for banks to maintain some form of IOU structure between themselves is averted. Furthermore, such a solution results in traders accruing relatively high-quality deposits at commercial banks with good reputation that can be in turn converted into central bank money, which also preserves a layered financial system with its specific advantages like competitiveness and innovativeness.

Of course, the evolution in payment netting and settlement is not over. Current debates on the need to improve cross-border payments and the possible future roles of central bank digital currencies and private sector payment options illustrate the universality of the challenges in this field and the importance for society to adjust and use new options granted by technological progress for the benefit of society.

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To demonstrate decentralised netting with bills of exchange, we can formulate the following proposition, whereby every credit circle of “n” entities (e.g. merchants, banks) can be netted with one bill of exchange, n-3 endorsements, and one bilateral netting. This proposition can be illustrated with the figure below and the following solution algorithm, starting from a closed credit circle. **First**, a bill of exchange is drawn with {Payer, Drawer, Payee} = {n, n-1, n-2}. This replaces the claim of n-2 on n-1 by a contingent claim of n-2 on n-1 (the guarantee), cancels the claim of n-1 on n, and creates a new claim of n-2 on n. **Second**, n-2 endorses the claim to the order of n-3, i.e. they pay their liability to n-3 with the bill, whereby they guarantee the bill as an endorser (i.e. n-3 now has a contingent liability on them). This cancels the claim of n-2 on n, as the claimant is now n-3. The bill is now {Payer, Drawer, Payee 1, Payee 2} = {n, n-1, n-2, n-3}. **Third**, n-3 endorses the bill and passes it on to n-4. The bill is now {Payer, Drawer, Payee 1, Payee 2, Payee 3} = {n, n-1, n-2, n-3, n-4}. This process is repeated further until its ultimate payee is entity 1. At maturity (or earlier), 1 and n can now net their mutual bilateral exposure, which includes the cancellation (or settlement) of the bill, implying also that all guarantees mature.

The diagram shows a directed graph with nodes labeled $n-4$, $n-3$, $n-2$, $n-1$, n , 1 , and 2 . The nodes are arranged in a roughly circular pattern. The edges and their markings are as follows:

- $n-4 \rightarrow n-3$: Yellow solid line with a blue tick mark.
- $n-4 \rightarrow n$: Yellow solid line with a blue tick mark.
- $n-3 \rightarrow n$: Red solid line with a yellow tick mark.
- $n-2 \rightarrow n$: Purple solid line with a red tick mark.
- $n-1 \rightarrow n$: Grey solid line with a purple cross mark.
- $n \rightarrow 1$: Green solid line with a blue cross mark.
- $1 \rightarrow 2$: Green solid line with a blue cross mark.
- $2 \rightarrow n-4$: Grey solid line with a blue cross mark.
- $n-3 \rightarrow n-2$: Red dashed line with a red tick mark.
- $n-2 \rightarrow n-1$: Purple dashed line with a purple tick mark.
- $n-1 \rightarrow 1$: Grey solid line with a purple cross mark.
- $1 \rightarrow n$: Grey solid line with a blue cross mark.
- $2 \rightarrow 1$: Grey solid line with a blue cross mark.
- $n-4 \rightarrow n-3$: Dotted line.
- $n-3 \rightarrow n-2$: Grey solid line with a red tick mark.
- $n-2 \rightarrow n-1$: Grey solid line with a purple tick mark.
- $n-1 \rightarrow n$: Grey solid line with a purple cross mark.
- $n \rightarrow 1$: Grey solid line with a blue cross mark.
- $1 \rightarrow 2$: Grey solid line with a blue cross mark.
- $2 \rightarrow n-4$: Grey solid line with a blue cross mark.