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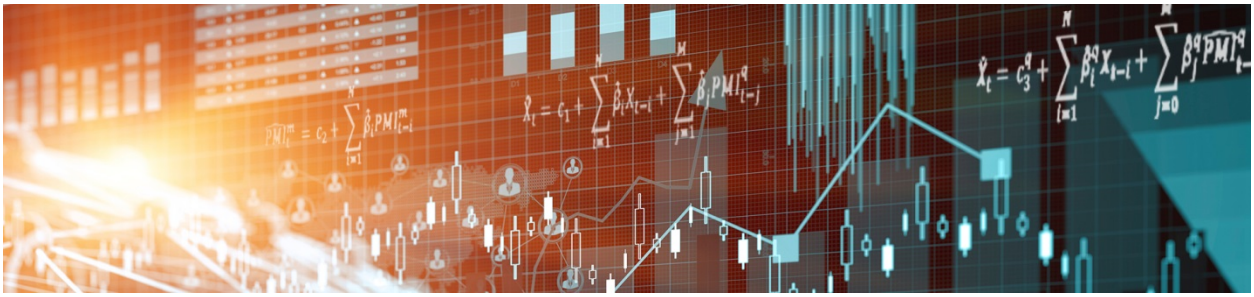

by Ben Fung, Scott Hendry and Warren E. Weber

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Swedish Riksbank Notes and Enskilda Bank Note: Lessons for Digital Currencies

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Abstract

This paper examines the experience of Sweden with government notes and private bank notes to determine how well the Swedish experience corresponds to that of Canada and the United States. Sweden is important to study because it has had government notes in circulation for more than 350 years, and it had government notes before private bank notes. Several differences between the experience of Sweden and that of Canada and the U.S. emerge. (i) Swedish bank notes were safe; in some cases, those of Canada and the U.S. were not. (ii) At certain times, Swedish government notes were not safe; government notes in Canada and the U.S. always were. (iii) Swedish private bank notes were a uniform currency without government intervention. Uniformity required government intervention in Canada and the U.S. (iv) Private notes and government notes coexisted in all three countries until governments took actions to drive private bank notes out of circulation. Using the experience of the three countries, the paper concludes that fiduciary digital currencies will likewise not be perfectly safe without government intervention. Further, the introduction of government digital currency will not drive out existing private digital currencies nor will it preclude private digital currencies from entering the market. Government intervention likely will be required for private and government digital currencies to be a uniform currency.

Bank topics: Bank notes; Financial services; Digital currencies
JEL codes: E41, E42, E58

Résumé

Cette étude se penche sur l'expérience de la Suède en ce qui a trait à la circulation de billets émis par l'État et par des banques privées afin de déterminer dans quelle mesure le cas suédois s'apparente à la situation qui prévalait au Canada et aux États-Unis. Le cas de la Suède est intéressant, puisque les billets d'État y circulent depuis plus de 350 ans, soit avant la mise en circulation des billets de banques privées. Plusieurs différences sont relevées entre les trois pays : 1) les billets des banques privées suédoises étaient sûrs, ce qui n'était pas toujours le cas de leurs équivalents canadiens et américains; 2) à l'inverse, il est arrivé que la sûreté des billets d'État suédois soit défaillante, alors que celle des billets canadiens et américains s'est toujours avérée; 3) les billets de banques privées en Suède constituaient une monnaie uniforme, même en l'absence d'intervention de l'État, alors qu'au Canada et aux États-Unis, les pouvoirs publics ont dû agir pour assurer l'uniformité monétaire; 4) dans les trois pays, les billets de banques privées ont circulé en même temps

que ceux émis par l'État jusqu'à ce que des mesures publiques soient prises pour les éliminer de la circulation. L'analyse des expériences suédoise, canadienne et américaine amène à conclure qu'il en irait de même pour les monnaies fiduciaires numériques : elles ne seront entièrement sûres que s'il y a intervention de l'État. De plus, l'introduction d'une monnaie numérique émise par l'État ne chassera pas les monnaies numériques privées existantes et n'empêchera pas l'émergence de nouvelles monnaies privées. Une intervention des autorités sera probablement nécessaire pour faire des monnaies numériques privées et de la monnaie émise par l'État une monnaie uniforme.

Sujets : Billets de banque; Services financiers; Monnaies numériques
Codes JEL : E41, E42, E58

Non-Technical Summary

In a series of papers, we have examined the experiences of Canada and the United States with notes issued by private banks and notes issued by either the country's government or its central bank. These notes share the essential characteristics of the digital currencies. Thus, the examination of the experiences with such notes can suggest lessons for what might be expected as the use of cash declines and is replaced by other media of exchange, some of which are likely to be digital currencies.

Our examination of the experiences of Canada and the United States with these notes uncovered several regularities.

(i) Private bank notes were not always perfectly safe; government notes were. Safety of private notes required government intervention.

(ii) Notes of different issuers did not always constitute a uniform currency. Bank notes regularly traded at discounts outside their local area. When uniformity was achieved, government intervention was required. A case of different government notes trading at discounts to each other occurred in Canada.

(iii) Private bank notes and government notes were able to circulate simultaneously until a government bank was given a monopoly on note issue.

A question is how general might these regularities be: Do they hold only for Canada and the United States or do they hold for other countries? This paper takes one step toward answering this question by examining the Swedish experience with notes to determine how well it corresponds to that of Canada and the United States. It also explores the reasons for any differences found.

With respect to finding (i), the Swedish experience confirms the finding for private bank notes. However, it does not confirm the finding with regard to government notes, as there were several cases when Swedish government notes were not safe. With respect to finding (ii), Sweden offers a case in which private bank notes were a uniform currency without government intervention. With regard to government notes, Sweden offers a second case in which they were not a uniform currency. The Swedish experience conforms to finding (iii).

Using the experience of the three countries, the paper concludes (i) that fiduciary digital currencies will not be perfectly safe without government intervention in the form of insurance or strong legislation; (ii) government intervention likely will be required for private and government digital currencies to be a uniform currency, although the possibility of uniformity without government intervention cannot be ruled out; and (iii) government digital currency will not drive out existing private digital currencies, nor will it preclude private digital currencies from entering.

1 Introduction

In a series of papers, we have examined the experiences of Canada and the United States with notes issued by private banks and notes issued by either a country's government or its central bank.[1] The reason for these examinations is that these notes share the essential characteristics of digital currencies. Thus, examination of the experiences with such notes can suggest lessons for what might expected as the use of cash declines and is replaced by other media of exchange, some of which are likely to be digital currencies.

Our examination of the experiences of Canada and the United States with these notes focused on whether they were safe, whether the notes of different issuers were a uniform currency and whether the notes of one type of issuer drove out the notes of other issuers. We uncovered several regularities. One was that private bank notes were not perfectly safe in the sense that note holders were not at all times able to redeem their notes for what was promised. In contrast, government notes were perfectly safe.

A second regularity was that the notes of different issuers did not constitute a uniform currency in the sense that they did not always trade for each other at the ratios of their stated monetary denominations. Instead, in both countries, we found periods when bank notes regularly traded at discounts outside their local area. For Canada, we also found a case where different government notes traded at discounts to each other.

A third regularity was that the private bank notes and government notes were able to coexist; e.g., both types of notes were able to circulate at the same time. The particular concern was the government notes would drive out private bank notes. The evidence showed this not to be the case.

Our examination of the experiences of Canada and the United States also looked at the role that private entities and the two governments played with respect to these regularities. With regard to note safety, we found that government intervention and legislation could make private bank notes perfectly safe. In both countries, these interventions took one of the following forms: (i) direct government insurance, (ii) a requirement that private issuers participate in a private insurance scheme, or (iii) laws extending the liability of stockholders and giving note holders first lien.

With regard to making private bank notes and government notes a uniform currency, we also found that there were government interventions that could accomplish this. In both countries, these interventions involved establishing a clearing mechanism for notes that put the costs of clearing on the note issuer rather than the note holder.

Lastly, we found that although private bank notes are no longer in existence, their demise was not due to their being inferior to government notes as media of exchange. Rather, it was due to government actions or legislation that made their issuance illegal, which may have been motivated by the idea that a monopoly on note issuance was necessary for a bank to act as a central bank.

The regularities described above pertain only to the experience of Canada and the United States. As such, they are based on a small and selective sample – two countries on the same continent with legal structures that came out of the legal traditions of the United Kingdom. Further, for most of the time period covered, approximately 1800 to 1950, both countries were either on a bimetallic gold/silver standard or on the gold standard. The question that

[1] These papers are Weber (2014); Weber (2015a); Weber (2015b) and Fung, Hendry, and Weber (2017)

then arises is how general might these regularities be: Do these regularities hold only for Canada and the United States and only for that time period, or are they more general, holding for other countries, for longer time periods, and for different monetary standards?

This paper takes a step toward answering this question by examining the experience of Sweden with government notes and private bank notes with respect to safety, uniformity and coexistence to determine how well the Swedish experience corresponds to that of Canada and the United States and to explore the reasons for any differences found. There are three reasons why the choice to study Sweden is a good one for beginning to answer this question:

(i) As Figure 1 shows, the time period in which notes were in existence is much longer. The first notes were issued in Sweden in 1661, whereas notes were not issued in the United States until 1784 and not issued in Canada until 1817.

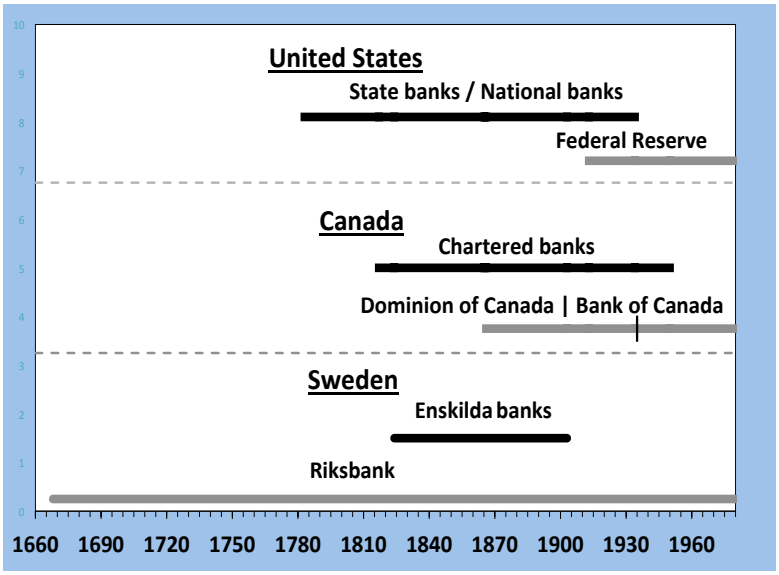

Figure 1: Time line of note issuance by banks (black lines) and by governments (dark gray lines) in the United States, Canada and Sweden

(ii) As Figure 1 also shows, government notes were in existence in Sweden for a long period before private bank notes were issued. In both Canada and the United States, private bank notes preceded government notes.

(iii) Sweden was on alternating copper and silver standards from 1624 to 1776, a silver standard from 1776 to 1873, and a gold standard from 1873 to 1931.[2] Thus, the Swedish experience allows for an exploration of how the choice of monetary standard could affect the experience with private and government notes.

[2]See Edvinsson (2010c) and Edvinsson (2012) for more discussion of the monetary standards in Sweden and how they changed over time.

The paper proceeds as follows. In Section 2, we discuss the history of the notes issued by a Swedish government bank, the Riksbank. In Section 3, we do the same for the notes of another government entity, the National Debt Office (NDO). In Section 4, we describe the experience with notes issued by Enskilda banks, private Swedish banks. In section 5, we discuss whether the Swedish experience leads us to modify the regularities regarding bank notes described above and if so, how. Section 6 concludes with some lessons for digital currencies today suggested by the historical experience with bank notes.

2 The Riksbank and Riksbank Notes

The most significant government entity that issued notes in Sweden is commonly referred to as the Riksbank or, more formally, the Sveriges Riksbank. However, an institution with that name did not come into existence until 1867, when the name of the *Riksens Ständer Bank* (RSB) was changed to Sveriges Riksbank. The RSB came into existence in 1668. It was continuously in operation under that name until the name change. It is for this reason that the Sveriges Riksbank is celebrating its 350th anniversary in 2018.

However, although the Sveriges Riksbank dates its beginning to the RSB, its beginning can be traced to an earlier bank, the Stockholms Banco. The Stockholms Banco was Sweden's first bank, and it was the first government-related entity to issue notes. Table 1 gives the important events that occurred with respect to note issuance by the Stockholms Banco, the RSB and the Sveriges Riksbank.

2.1 The Stockholms Banco, 1657-1664

On 30 November 1656, King Karl X Gustav issued the royal charter for the Stockholms Banco to Johan Palmstruch and his company, which meant that the original charter was for a private bank. However, the charter was changed shortly after it was issued so that "one half of the Bank's net profit would accrue to the Crown and the other half was to be divided equally between the City of Stockholm and Palmstruch's company.... [Further,] the King reserved the right to appoint bank commissioners (managers)" (Wetterberg 2009, 33). Thus, the government was involved with the Stockholms Banco from its very beginning.

The Stockholms Banco opened its doors for business on 29 July 1657. Initially the bank was able to carry out its business of making loans based on the large amounts of copper deposited with it when it opened. However, a change in the mint equivalent of copper in 1660 reduced the value of newly minted copper money relative to the old copper money and "clients rushed to the bank to withdraw [copper] plate money of the same kind as they had deposited earlier" (Wetterberg, 2009, 37). To overcome the shortage of money that resulted from this contraction of deposits, the bank began issuing notes in July or August of 1661.

The Stockholms Banco's notes were novel in that they were not issued against deposits in the bank, unlike the notes that had been issued previously by Italian banks. Instead, they were issued strictly on the credit of the bank, as were the notes issued by banks in Canada and the United States in the 1800s. More of the similarity between the Stockholms Banco's notes and those of Canadian and U.S. bank notes can be seen from this translation of one of them:

Year	Event
	Stockholms Banco, 1557-1664
1657	opens doors
1661	first issues notes
1664	fails
	RSB, 1668-1867
1668	takes over Stockholms Banco
≈1701	begins to issue "transfer notes"
1726	transfer notes become legal tender
1745	suspends payment on notes
1777	resumes payment on notes; notes depreciated; new monetary unit
1809	suspends payment on notes
1834	resumes payment on notes; notes again depreciated
	Sveriges Riksbank, 1867-
1867	*Riksens Ständer Bank* renamed Sveriges Riksbank
1873	Sweden goes on gold standard; adopts *krona* as new monetary unit
1897	Sveriges Riksbank established as Sweden's central bank; monopoly on note issuance

Table 1: Timeline of note issuance by the Stockholms Banco, the RSB and the Sveriges Riksbank

> That the holder of this Note of Credit has a claim upon the Bank of Stockholm, under No. 17269, for Twenty-Five Dollars Copper Money, this be hereby certified by us undersigned, Commissioners of the Bank and Accountants, as also verified through the Seal of the Bank, hereto appointed. Given in the Bank of Stockholm, An. 1663, *the 4th November.* Dollars 25 Copper Money. (Signatures and Seal. Only words in italics written by hand) (Heckscher 1934, 170).

Sweden was officially on a copper standard at this time. A major difficulty with this copper standard was that copper coins were heavy and difficult to transport:

> The largest coin, of 10 dollars "silver money" in copper, had a weight of not less than 19.7 kilograms and has been called the heaviest coin ever known. Even the most usual denomination, the "plate" (*plåt*) of two dollars 'silver money', in 1661 weighed more than 3.2 kgs. . . . and even the payment of small sums made the use of carriers and horses necessary (Heckscher 1934, 170).

These difficulties with using copper coins as media of exchange helped the Stockholms Banco's notes go into circulation. According to Edvinsson (2010b, 162), "Initially, the bank notes were quite popular with the public, since they were a more convenient means of payment than the metal coins (in particular the heavy copper plates). There was even a

small premium on the notes relative to metal coins." The popularity of the notes is shown in Figure 2. The quantity of notes in circulation reached almost 2.8 million *daler kopparmynt* in 1665.[3]

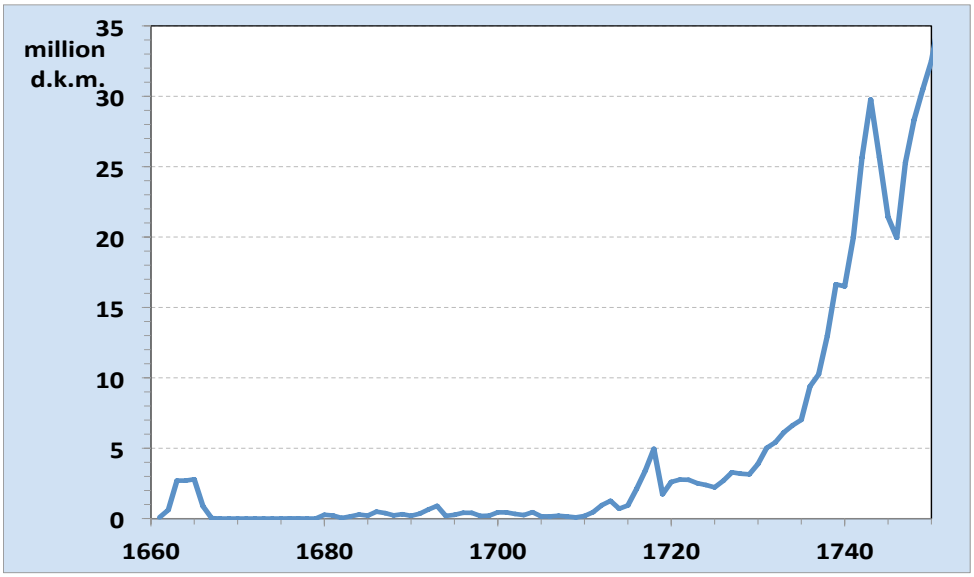

Figure 2: Stockholms Banco and *Riksens Ständer Bank* notes in circulation, 1660-1750[4]

2.2 The *Riksens Ständer Bank*

Early years, 1668-1745

As Table 1 shows, the Stockholms Banco did not last long. Starting in 1663, likely due to the large quantity of loans the Stockholms Banco made through note issuance without a corresponding increase in its stock of copper money, the bank began to face large demands to redeem its notes in copper money. The loss of copper forced the Stockholms Banco to stop redeeming its notes in the next year. As a result, "The Riksdag (the Diet of the Estates of the Realm) decided to withdraw the notes. This was done at their full value" (Edvinsson 2010b, 163). Figure 2 shows that the quantity of Stockholms Banco notes fell after 1665 and was zero by 1668.

[3]The units of account for the two main currencies in circulation at the time were the *daler silvermynt* (d.s.m.), which had 1 *daler* = 4 marks = 32 *öre*, and the *daler kopparmynt* (d.k.m.), which also had 1 *daler* = 4 marks = 32 *öre*. The systems started with 1 *daler* d.s.m. = 1 *daler* d.k.m. However, in 1633 the ratio was changed to 1 *daler* d.s.m. = 2 *daler* d.k.m.; in 1643, to 1 *daler* d.s.m. = 2.5 *daler* d.k.m.; and in 1665, to 1 *daler* d.s.m. = 3 *daler* d.k.m. This ratio remained until 1777.

[4]Source: "Notes" Table A7.1, Edvinsson and Ögren (2014).

The Riksdag officially took over the Stockholms Banco in the fall of 1668 and changed the name to the *Riksens Ständer Bank*, Bank of the Estates of the Realm.[5] The RSB was prohibited from issuing credit notes, and Figure 2 shows that the quantity of notes was zero from 1668 to 1675.

However, the difficulties of exchanging with copper coin led the RSB to find ways around this prohibition. One was the use of "approved assignments" (*approberade assignationer*).[6] The second was the use of "transfer notes," which began to be issued by the Bank around 1701.[7] The two types of notes differed by the way in which they were obtained from the Bank and by the requirement that transfer notes had to have the signature of the person to whom they were given.

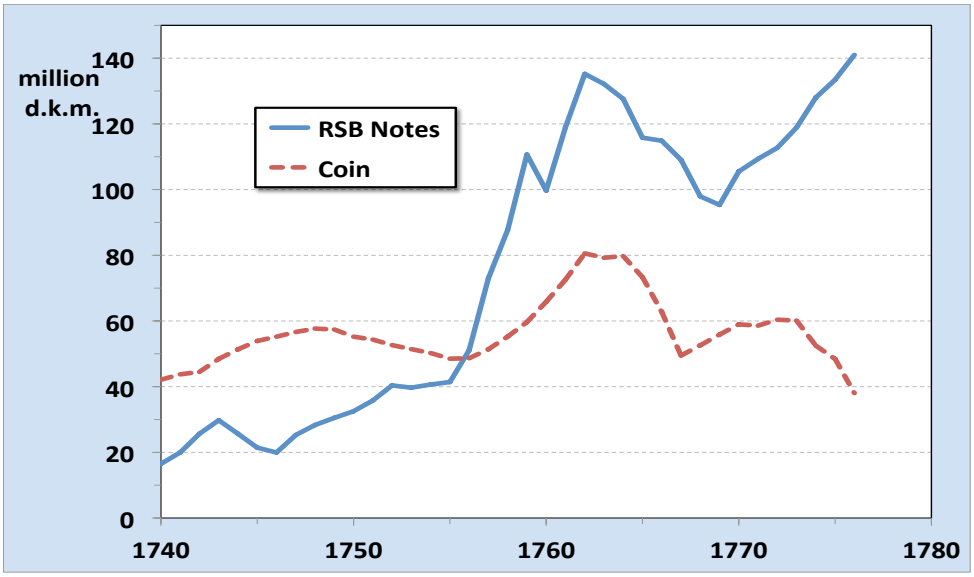

Figure 3: Quantity of RSB notes and coin in circulation, 1740-1776 [8]

Nonetheless, the quantity of notes in circulation remained small (less than 1 million d.k.m.) and relatively constant until the early 1720s, when note growth started increasing. According to Wetterberg (2009, 88), the reasons for the increase in the growth in the quantity of RSB notes were:

[5]The four estates were the Nobility, the Clergy, the Burghers, and the Peasants. The four estates met in the Riksdag, the Diet or parliament. The other parts of the Swedish government at the time were the king and the Council of the Realm. Thus, even though both the Stockholms Banco and the RSB were heavily involved with the Swedish government, there was a marked difference between them. The Stockholms Banco was tied to the Swedish king; the RSB was run by the Riksdag.

[6]See Wetterberg (2009, 58) for a discussion of approved assignments.

[7]Edvinsson and Ögren (2014, 301) refer to these notes as "transportation notes" and state that they resembled cashier's checks more than the bank notes of today.

[8]Source: "Coins, including coin tokens" and "Notes" Table A7.1, Edvinsson and Ögren (2014).

> In 1726, transfer notes became legal tender in the collection of revenue, which meant that people could use them to pay taxes and other public dues. Four years earlier, the bank . . . decided to lower the minimum amount for a transfer note to 50 *d km*, a sixth of the minimum of 100 *d sm* that had been set in 1701.

Fiat money, 1745-1776

The growth of notes issued by the RSB continued until 1743, when it reached close to 30 million d.k.m. The large increase in notes outstanding in the early 1740s was due to a war with Russia. However, the value of the bank's notes in terms of silver fell in the early 1740s. This led to a large demand for note redemption, as shown by the decline in note circulation after 1743 in Figure 2. The loss of metal reserves led the bank to stop redemptions beginning 23 October 1745.

However, as Figure 3 shows, stopping redemptions did not mean that the RSB stopped issuing notes. The quantity of RSB notes exceeded the quantity of coin beginning in 1757 and remained larger throughout the remainder of the period. Thus, for a period of almost 20 years, Sweden's media of exchange was more fiat money than commodity money.

Resumption and a change in the Swedish monetary system, 1777

The RSB resumed payments on its notes in 1777. That year also marked two major changes in the Swedish monetary system. The first was that the two old accounting systems with the *daler*/mark/*silvermynt* and *daler*/mark/*kopparmynt* as denominations were replaced by a single system with the *riksdaler* (sometimes also referred to as the *riksdaler specie*) as the main currency unit. The *riksdaler* was divided into 48 *skillings*.

The second major change was that the notes of the RSB were once again made convertible. However, the conversion was not at the old exchange rate of 1 *riksdaler* = 36 marks *kopparmynt* (k.m.). Instead, it was done at the rate of 1 *riksdaler* = 72 marks *kopparmynt*.[9] Thus, note holders lost 50 percent of the value of their notes in terms of the unit of account. They also lost in terms of value. The *riksdaler* was trading at 40 marks k.m. per *Hamburger reichtaler banco* in 1745 before the RSB stopped redemptions. At the end of 1776, that rate was around 69 marks k.m.[10]

A RSB note from 1804 is shown in Figure 4. The note states, " In exchange of this note *Riksens Ständer Bank* fourteen shillings in copper coins."[11]

Fiat money again, 1809-1834

Figure 5 shows that after the resumption of payments on RSB notes, the quantity in circulation fell until the end of 1802, after which it began to increase again, and there were huge increases in total bank notes beginning in 1808. When the large increases began, they were necessitated to defend against Russia's attack on Finland in 1808. Finland was a part of Sweden at the time. The increase in notes led to a drain on the RSB's silver reserves.

[9]These rates are from Table 2.3 in Edvinsson (2010c).

[10]These exchange rates are from Edvinsson (2010a, Table 5.6). The exchange rates of the *riksdaler* against the *Amsterdam rijksdaalder courant* and the pound sterling show the same amount of depreciation of the currency over this period.

[11]We thank Björn Segendorf for the translations of this note and the other Swedish bank notes shown.

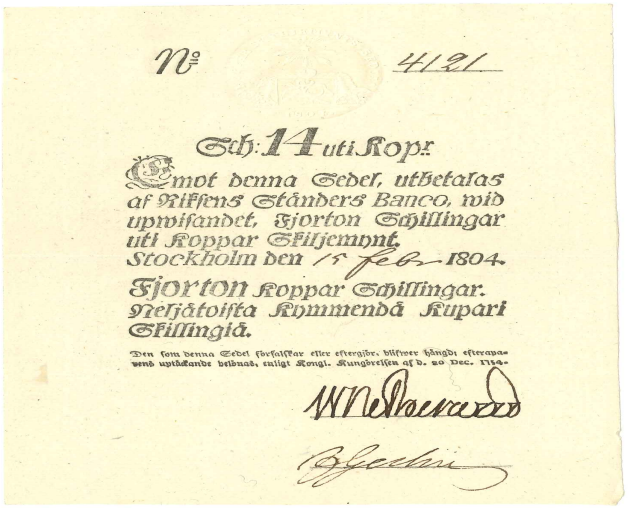

Figure 4: A *Riksens Ständer Bank* note, 1804

As a result, the RSB imposed a limited suspension of convertibility of its notes beginning in 1809. A total suspension of convertibility began in 1818.

Heckscher (1934) summarizes the monetary history of Sweden from 1745 to 1834 as "Sweden then [in 1834] had had a system of paper money since 1745, with interruptions only during the periods 1777-89 and 1803-07, almost a record in the existence of a non-metallic currency" (Heckscher (1934, 185)).

Resumption until the name change, 1834-1867

The RSB resumed payments on its notes in 1834. However, once again there was a depreciation. The old rates were 1 *riksdaler specie* = 1 *riksdaler banco* = 48 *skillings*. The new rate was *riksdaler specie* = $\frac{8}{3}$ *riksdaler banco* = 128 *skillings*, which translates to a 62.5 percent depreciation. A RSB note from 1859 is shown in Figure 6. The note states, "*Sveriges Riks Ständers Bank* will on request in exchange of this note pay one *Riksdaler Riksmynt* with $\frac{1}{4}$ *Riksdaler* in silver or 2 *Ort Gulf–lödigt* coined silver. The one who forges

[12]Source: 1777-1845 "Riksbank notes, mn *riksdaler banco*" Table A7.2; 1846-1867 "Riksbank notes outside the Riskbank" Table A7.3 Edvinsson and Ögren (2014). The data in terms of *riksdaler banco* are converted to SEK using 1 *riksdaler banco* = 1.5 SEK as per Table 8.1, Fregert (2014). SEK notes in units of the Swedish *krona*, the monetary unit adopted in 1873.

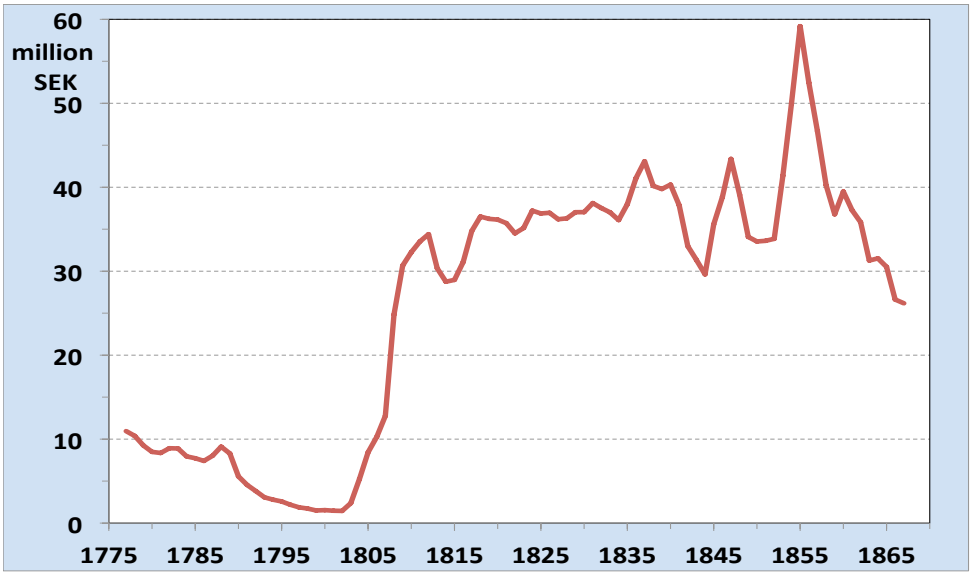

Figure 5: RSB notes in circulation, 1776-1867 in SEK[12]

Figure 6: A *Riksens Ständer Bank* note, 1859

this note will be punished according to the law but the one who exposes the forger will be rewarded in accordance to the Kings announcement of 8 July 1818."

2.3 The *Sveriges Riksbank, 1867-*

The name of the *Riksens Ständer Bank* was changed to *Sveriges Riksbank* in 1867. No major change in its note issuance or in Sweden's monetary standard accompanied the change in name. A major change did occur in 1873 when Sweden adopted the gold standard and established the *krona* as the new monetary unit. The *krona* was set equal to $\frac{1}{2480}$ kilograms of gold, and the notes of the *Sveriges Riksbank* were made payable in gold. The exchange rate between the *krona* and the *riksdaler banco* was set so that holders of old notes did not lose in the transition. A *Sveriges Riksbank* note from this period is shown in Figure 7. The note states, "*Sveriges Riksbank* will against this note pay one hundred kronor in gold coins according to the law on nations coins of 30 May 1873."

Another change that occurred during this period was that the *Sveriges Riksbank* was given the monopoly on note issuance by the Riksbank Act of 1897. The monopoly formally began in 1903.

Figure 7: A *Sveriges Riksbank* note, 1916

3 National Debt Office, 1789-1803

Sweden was at war with Russia again from 1788 to 1790. The king wanted to borrow from the RSB to finance the war, but the RSB turned him down. It was reluctant to make large loans to the government because it wanted to maintain the convertibility of its notes.

Year	Event
1789	first issues interest-bearing inconvertible notes
1791	interest payments discontinued
1803	notes made convertible into RSB notes
1845	finally go out of circulation

Table 2: Timeline of note issuance by the National Debt Office

As a result, the government set up the National Debt Office (*Riksgäldskontoret*), a second note-issuing entity.

The first NDO notes were issued in 1789. These notes were inconvertible, unlike the notes issued by the RSB, which remained convertible. The NDO notes circulated at a floating exchange rate to the notes of the RSB. Thus, during this period there were three units of account: the *riksdaler specie*, which referred to the silver coin; the *riksdaler banco*, which referred to RSB notes; and the *riksdaler riksgälds*, which referred to the NDO notes. RSB notes circulated at a premium to NDO notes presumably because they were convertible. These premia between 1789 and 1805 are shown in Figure 8. The figure shows that the premia were around 10 percent until 1797, when they showed a marked increase. The reasons are unclear, but the increase in the premium on RSB notes may have been due to economic problems Sweden was experiencing at the time.

As Figure 9 shows, a large quantity of these notes went into circulation up to 1803 and they had the effect of almost driving RSB notes out of circulation. There were several reasons for the popularity of NDO notes. One was that they were accepted in payment of taxes. Another was that they were issued in smaller denominations than RSB notes. A third was that initially they were interest-bearing. However, interest payments were discontinued in 1791.[13] The RSB did not accept NDO notes in payments or for deposits.

The float between NDO notes and RSB notes ended in 1803 when NDO notes were made convertible to RSB notes at the rate of 1 *riksdaler banco* = 1.5 *riksdaler riksgälds*.[16] According to Fregert (2012, 57), "This implied a devaluation rate of the *Riksdaler riksgäld* notes at 50 percent relative to the initial promise in 1788 at one to one." Figure 9 also shows that after this announced rate of conversion, the relative circulation of the two types of notes reversed, with RSB notes becoming predominant. However, some NDO notes remained in circulation, presumably because they were issued in smaller denominations than the RSB notes. NDO notes eventually were taken out of circulation in 1845.

[13]See Wetterberg (2009, 130).

[14]Source: "Premium on *riksdaler banco* notes, end of year (%)" Table A7.2, Edvinsson and Ögren (2014).

[15]Source: "Riksbank notes, mn *riksdaler banco*" and "*Riksgälds* notes, mn *riksdaler riksgälds*", Table A7.2, Edvinsson and Ögren (2014). RSB notes converted to *riksdaler riksgälds* using 1 *riksdaler banco* = 1.5 *riksdaler riksgälds*.

[16]Edvinsson (2010c, 47).

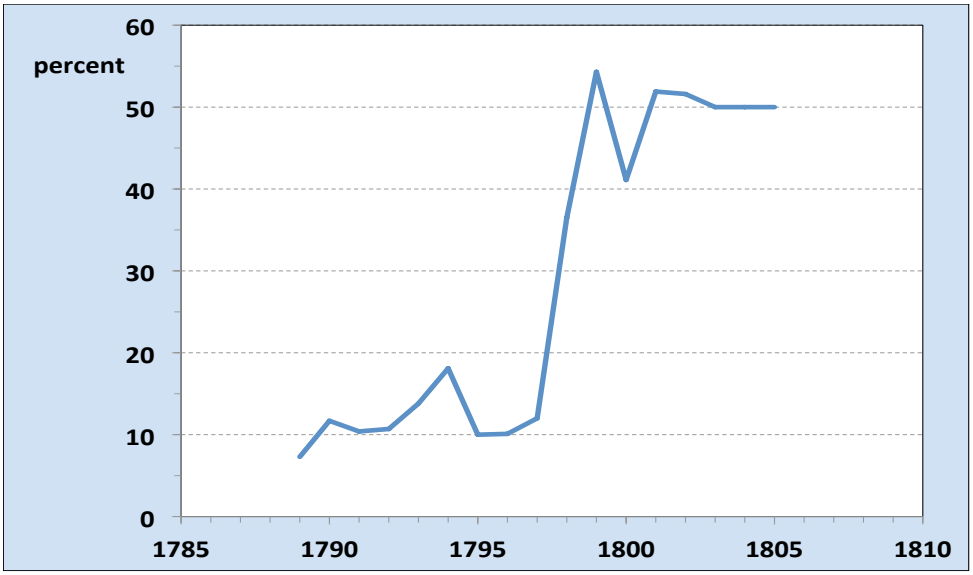

Figure 8: Premium on RSB notes over NDO notes, 1789-1805[14]

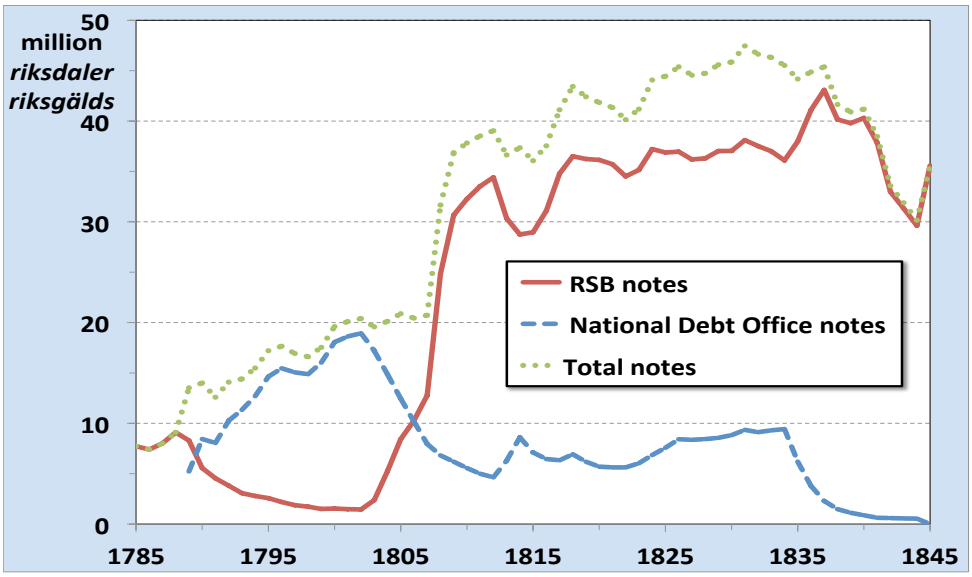

Figure 9: NDO and RSB notes in circulation, 1776-1845[15]

4 Enskilda Banks, 1824-1903

Year	Event
1824	banks authorized
1831	first bank opens for business and issues notes
1897	Riksbank given monopoly on note issuance
1903	notes go out of circulation

Table 3: Timeline of note issuance by Enskilda banks

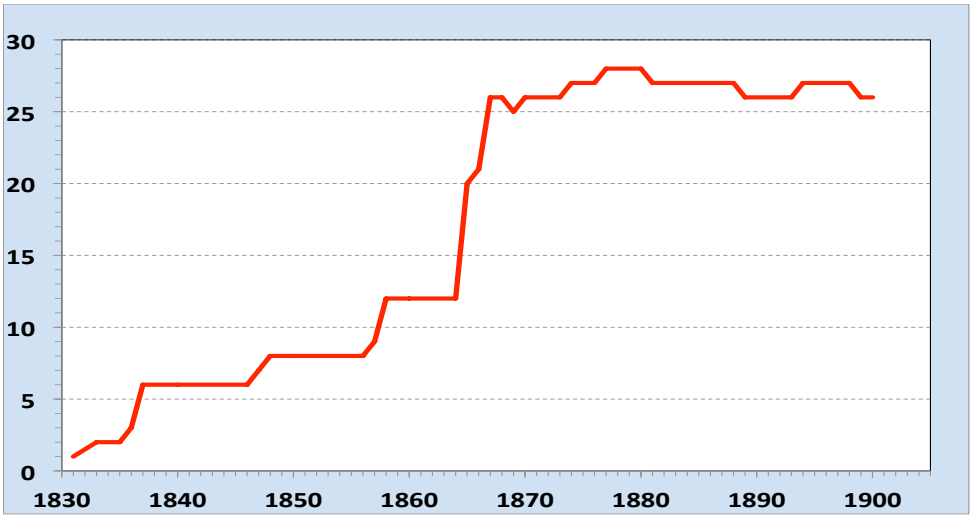

Figure 10: Number of Enskilda banks in operation over 1831-1900[17]

Private banks (Enskilda banks) were not authorized in Sweden until the royal proclamation of 1824. The first private bank, the Skånska Privatbank (later *Skånes Enskilda Bank*), located in Ystad, opened for business on 5 April 1831. A second Enskilda bank, the Wermlands Provincial Bank, opened in 1833. As Figure 10 shows, four more Enskilda banks were chartered between 1835 and 1837. However, no new Enskilda banks opened again until 1846. There was a burst of new Enskilda bank openings between 1864 and 1866 when 13 new banks opened. By 1875, 26 Enskilda banks were in operation. The number of Enskilda banks in operation remained almost constant over the next 30 years.

The *Skånes Enskilda Bank* immediately began to issue small-denomination non-interest-bearing certificates payable to bearer "that for all practical purposes were identical to bank

[17]Authors' construction based on Figure 4.2 in Ögren (2003).

notes.... The note issuing activity ...was clearly illegal.... Still, the government did not stop the notes of the Ystad bank" (Jonung, 2007, 7-8).[18] The Stora Kopparbergs Läns och Bergslands Enskilda Bank, which opened in 1835, was the first Enskilda bank that was licensed to issue notes. A note from the Helsinglands Enskilda bank is shown in Figure 11. The note states that the "Helsinglands Enskilda Bank will on request in exchange of this note pay ten Kronor."

Figure 11: A 10 kronor Enskilda bank note, 1879

Although the proclamation of 1824 did not contain any provisions regarding bank notes, it did contain three provisions bearing on note issuance. The first was that Enskilda banks were to be "organized as a joint business partnership (*handelsbolag*) with unlimited liability" (Jonung, 2007, 5). The second was that banks should not expect to receive any government funds or government support of their activities. The third was that banks were permitted to establish branches.

The charters of the six Enskilda banks in business in the early 1840s were to expire in 1847. Before this happened, the government put forth a new law in 1846 regarding banks. It not only maintained the unlimited liability of bank shareholders, but also contained the provision that "A shareholder of the bank or his heirs was not entitled to withdraw during the term of the charter to sell his shares, unless the company gave its consent at a general meeting" (Jonung, 2007, 9). With regard to notes, it required that they be payable to bearer

[18]Jonung explains the statement that the issue of notes by the *Skånes Enskilda Bank* was illegal by arguing that "the proclamation of 1824 did not mention the issuance of private notes" and that "other laws clearly prohibited the supply of private notes" (Jonung, 2007, 6).

on demand and placed a restriction on the total amount of notes that a bank could issue based upon the sum of its vault cash, deposits at the Riksbank, and securities up to 50 percent of its capital stock. However, there was no reserve requirement against note issuance in terms of specie or RSB notes. A minimum denomination of 5 *kronor* was also set.

Some additional requirements on note issuance were made in 1855. The ones worth noting here were that the minimum denomination remained at 5 *kronor* and that the notes of all banks were to be of the same denominations and that all notes of a particular denomination were to be of the same physical size.

More clarifications and changes with regard to note issuance were made in the bank law of 1864. The first was to restrict the denominations of Enskilda bank notes to 5, 10, 100 and 500 *kronor*. The second was to require that notes be redeemed in coins or notes of the Riksbank if presented at the bank's principal office. If payment was not made on demand, the note holder was entitled to the principal plus 6 percent interest from the time of the demand until payment was made on the note.

Other modifications affecting Enskilda banks were made in 1873. One of these was that permission for Enskilda banks to issue 5 and 10 *kronor* notes was granted only temporarily. The permission was removed around 1880.

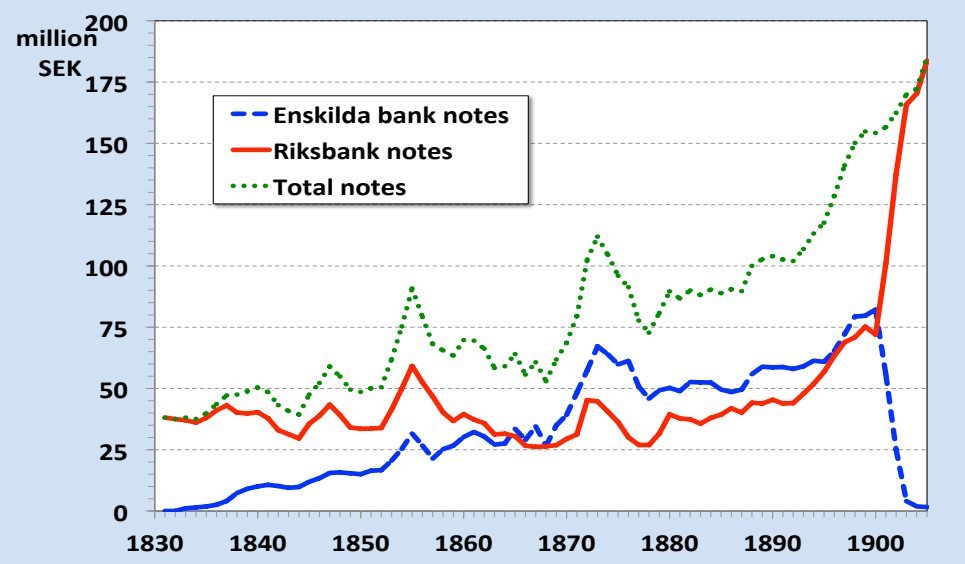

Figure 12: Enskilda, Riksbank, and total bank notes, 1831-1903[19]

The quantity of notes in circulation issued by Enskilda banks, by the Riksbank, and the total is shown in Figure 12. Figure 13 shows that although note issuance by Enskilda banks

[19]Source: 1777-1845 "Riksbank notes, mn *riksdaler banco*" and "Private bank notes" Table A7.2; 1846-1903 "Riksbank notes outside the Riskbank" and "Private bank notes" Table A7.3, Edvinsson and Ögren (2014). The data in terms of *riksdaler banco* are converted to SEK using 1 *riksdaler banco* = 1.5 SEK.

got off to a slow start, it was an increasing fraction of the total supply of bank notes in circulation from 1831 until 1876. For the period 1865 to 1900, the notes of Enskilda banks made up over 50 percent of the total notes in the Swedish economy, with Enskilda banks' fraction of the total reaching a maximum of almost $\frac{2}{3}$ of total notes in 1876. One reason the quantity of Riksbank notes in circulation fell is that Enskilda banks held a large quantity of them as reserves.

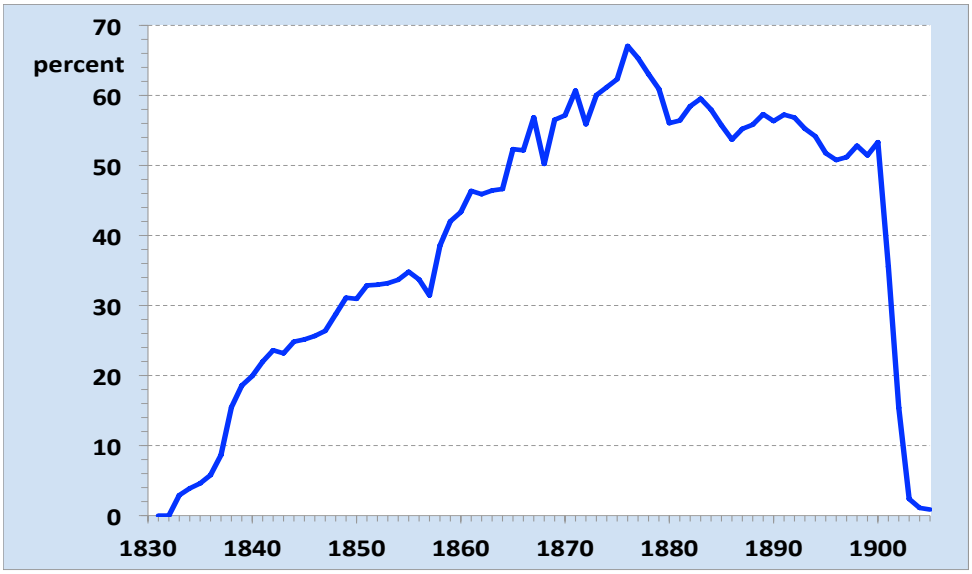

Figure 13: Enskilda bank notes as a fraction of total bank notes issued, 1831-1903

The decline in the importance of Enskilda bank notes after the passage of the 1897 law giving the Riksbank the monopoly on note issuance is shown in Figures 12 and 13.

5 Swedish Bank Note Experience Compared with that of Canada and the United States

In our previous studies of Canada and the United States, we examined three episodes of private bank notes: notes issued by Canadian banks from 1817 to 1950, notes issued by U.S. state banks from 1783 to 1863 and notes issued by U.S. national banks from 1863 to 1934. We also examined two episodes of government notes: Dominion notes and Bank of Canada notes from 1866 to the present and Federal Reserve Notes in the United States from 1913 to the present.

As discussed in the introduction, we uncovered several regularities about the experience with bank notes from studying these episodes. In this section we examine the extent to which the Swedish experience with bank notes is consistent with the experiences of Canada

and the United States and, in those cases where the experiences are different, we present modifications of the regularities to reflect the Swedish experience.

5.1 Safety

Private bank notes

In both Canada and the United States, we found periods during which private bank notes were not perfectly safe in the sense that note holders were not able to redeem their notes for what was promised. Some holders of U.S. state bank notes suffered losses as did some holders of Canadian bank notes prior to 1881. However, in both countries, we also found periods during which private bank notes were perfectly safe. No holders of U.S. national bank notes suffered losses, nor did any holders of Canadian bank notes after 1881.

For each of the periods during which private bank notes were perfectly safe, we could identify a government intervention or legislation that was not in place during the episodes when bank notes were not safe. The government interventions took one of the following forms: (i) direct government insurance in the case of U.S. national banks or (ii) a requirement that private issuers participate in a private insurance scheme, the Bank Note Redemption Fund, in the case of Canadian banks after 1890. The government legislation was laws extending the liability of stockholders and giving note holders first lien again in the case of Canadian banks, this time after 1881.

This finding for Canada and the United States suggests that government intervention or legislation is sufficient for private bank notes to be safe, but leaves open the question of whether such government intervention or legislation is necessary for private bank notes to be safe. The Swedish experience would seem to be one piece of evidence for the position that such government action is not necessary. Enskilda bank notes were perfectly safe. No Enskilda bank note holders suffered losses. Although one Enskilda bank, the Wadstena Enskilda bank, failed due to embezzlement, there were no losses on its notes as it was taken over by another bank. Further, according to Engdahl and Ögren (2008, 86), "Not even this episode led to discounts of the bank's notes. Instead the notes were refused as means of payment until another bank guaranteed the liabilities of this bank."[20,21] Yet, direct government intervention to protect Enskilda note holders was explicitly ruled out. The various acts regarding Enskilda banks stated that banks should not expect to receive any government funds or government support of their activities.

Using the Swedish Enskilda bank experience to support the argument that some form of government intervention is not necessary for private bank notes to be safe is not correct, however. In fact, the opposite is the case. The Swedish experience adds support to the conclusion that some type of direct government intervention is necessary for private bank note safety because Enskilda banks received direct government support on two occasions. The first was during the crisis of 1856-1857. In December 1857, the *Skånes Enskilda Bank* threatened to suspend payment on its notes, which would have caused losses to note holders

[20] We would dispute the "no discounts" characterization. To us, refusal seems to be a 100 percent discount.

[21] The experience of Sweden with Enskilda notes is well summarized by Jonung (2007, 23): "During the seventy years of competition between private notes and *Riksbank* notes, none of the *enskilda* banks ... went bankrupt, causing holders of private notes to incur losses, nor was any bank forced to close – even temporarily – due to financial panics by the public on banks."

during the period of suspension. The Riksbank responded by offering it a credit of 500,000 kroner. In addition, the Riksbank took out a loan in Hamburg that could provide emergency credit to Enskilda banks. The second occasion was during the crisis of 1878-1879. Some Enskilda banks, the Stockholms Enskilda Bank in particular, held large amounts of railroad bonds. Beginning in 1875, the prices of railroad bonds fell by more than half their value, which led to doubts about the solvency of some banks. In this crisis, the government set up the Railroad Mortgage Fund in May 1879 to provide banks with discounts based on railway bonds. According to Ögren (2003, 261), the Fund, acting like a lender of last resort, "unquestionably was significant in saving one important bank, Stockholm Enskilda Bank, from bankruptcy."

The Swedish Enskilda bank experience further suggests that government legislation, at least legislation that extends the liability of shareholders without giving first lien to note holders, may be insufficient to insure the safety of private bank notes. Shareholders of Swedish banks had unlimited liability, but note holders did not have first lien, and there were the threats to bank note safety discussed above. Likewise, shareholders in Canadian banks were subject to extended liability, in this case double liability, yet some note holders still experienced losses. It was not until 1881, when note holders were given first lien on a bank's assets, that Canadian bank notes became perfectly safe.

Government bank notes

Dominion notes issued by the Canadian government, notes issued by the Bank of Canada and notes issued by the Federal Reserve were perfectly safe. Holders of these notes never suffered losses. In our previous work, we came to the conclusion that this would be the case for all government notes, based on this experience.

The Swedish experience with government notes has led us to change this conclusion. The notes issued by the RSB were not safe. There were two instances when it suspended payments and note holders suffered losses when it resumed. Also, when the notes of the NDO were made convertible into RSB notes, it was done at a loss compared with what was expected when they were originally issued.

5.2 Uniformity

Private bank notes

In both Canada and the United States, we found periods during which notes issued by different private banks did not constitute a uniform currency in the sense that they did not always trade for each other at the ratios of their stated monetary denominations. Instead, in both countries, we found periods when bank notes regularly traded at discounts outside their local area. However, in both countries, we also found periods during which private bank notes were a uniform currency. In Canada, private bank notes were a uniform currency after 1890, and in the United States, the notes of national banks were always a uniform currency.

For each of the periods during which private bank notes were a uniform currency, we could identify a government intervention or legislation that was not in place during the episodes when bank notes were not a uniform currency. In Canada, the government legislation was the requirement that banks either establish a redemption office or make an arrangement with another bank for their notes to be redeemed in specie in the country's commercial centers.

In the case of national banks in the United States, it was the government's establishment of a facility where a national bank could send the notes of other national banks and receive the par value in specie in return. Without this facility, it is likely that national banks would have discounted or even not accepted the notes of other banks, because notes of other national banks did not count as reserves against deposits.

This finding for Canada and the United States suggests that government intervention or legislation is sufficient for private bank notes to be a uniform currency. Further, since private bank notes were not uniform currencies in the absence of such government actions, the previous findings for Canada and the United States also suggest that such government interventions are necessary for uniformity.

However, in the United States there was one exception to the finding that uniformity could not be achieved without government intervention. This exception was the Suffolk Banking System, which was a private clearing system for notes of state banks that arose in New England. Notes of the banks that participated in the system exchanged at par throughout New England.

The Swedish experience adds another exception. Although Enskilda bank notes did not start out as a uniform currency, they became one over time without government intervention:

> The first private [Enskilda] banks did not always accept the notes of other private banks at par. Gradually, however, they agreed to redeem each other's notes on demand at par. Furthermore, the note exchangers of the private banks exchanged the notes of other private banks. In this way, the *enskilda* banks maintained collectively the full convertibility of their notes (Jonung, 2007, 19).

Ögren (2003, 152) dates this system of Enskilda banks accepting the notes of other banks at par "back at least to the legislation of 1846." He also states that in 1856, the Stockholms Enskilda Bank established a clearing system for Enskilda bank notes.[22]

A plausible reason for the difference between the Swedish experience and that of Canada and the United States, implicit in Jonung (2007), is that accepting the notes of other banks at par was a way for Enskilda banks to promote the circulation of their notes to compete with Riksbank notes. When Canadian and U.S. banks began to issue notes, they did not have to compete with government notes, as there were none. In contrast, when the first Enskilda banks began operating, Riksbank notes were the predominant medium of exchange. Thus, they had to take measures to help make their notes competitive with Riksbank notes. Accepting the notes of other banks at par may have helped Enskilda banks through a network effects externality. If Bank A accepts the notes of Bank B at par and Bank B does the same, then people might see the notes of both banks as more acceptable, increasing the competitiveness of the notes of both banks against government notes.

Getting their notes into circulation was important for the Enskilda banks' business model because notes, rather than deposits, were the way in which their customers preferred to

[22] "When A.O. Wallenberg founded Stockholms Enskilda Bank, one of his principal ideas was to relieve banks of this constraint [of having to make transfers between them in Riksbank notes and coins]. His bank would assist its provincial cousins by settling the mutual claims, arranging their customers' distant payments and meeting the need to exchange notes for other notes as well as with the national currency" (Wetterberg, 2003, 197).

receive loans. According to Ögren (2003, 144), "Since the offices of commercial banks were both few and seldom open, bank notes were vastly more convenient for transactions than were deposits." In addition, such a mutual agreement might have meant that banks could keep their notes in circulation longer, which would increase their profitability.

Government bank notes

In Canada, we found a case in which different government notes were not a uniform currency. Between 1868 and 1881, the government issued Dominion notes that were payable in Montreal and Dominion notes that were payable in Toronto. Although we do not have direct evidence, it appears that these notes did not trade at par in all instances.

The Swedish experience with notes by different government issuers was similar to the Canadian experience with notes of different government issuers. In Sweden between 1789 and 1845, there were two distinct government notes: Riksbank notes and NDO notes. These notes exchanged at a floating rate until 1803 when the NDO notes, which were previously inconvertible, were made convertible into Riksbank notes.[23]

In both the Canadian case and the Swedish case, the different notes eventually were made uniform currencies through government intervention. In Sweden, the government established and maintained a fixed exchange rate between the Riksbank notes and the NDO notes. In Canada, the government intervention was to remove the specification of where the notes were payable, so that all Dominion notes were payable at all Receivers General offices.

Enskilda bank notes and Riksbank notes also eventually became a uniform currency. Both Enskilda banks and the Riksbank took actions to make the two different types of notes a uniform currency. On the Enskilda banks side, they "maintained an exchange of one to one to *Riksbank* notes uninterruptedly as long as private notes were circulating" (Jonung, 2007, 24). On the Riksbank side, "In 1869, the Riksbank began accepting Enskilda bank notes at par, as long as these notes could be redeemed for Riksbank notes in a city where the Riksbank maintained an office"(Ögren, 2003, 152). Thus, for at least the last 30 years that Enskilda bank notes were in existence, they and Riksbank notes formed a uniform currency for Sweden.

5.3 Coexistence

The evidence from Canada, Sweden, and the United States shows that private bank notes and government bank notes can coexist. In Canada, private bank notes and government notes (Dominion notes and, later, Bank of Canada notes) coexisted from 1868 to 1950. In Sweden, Enskilda bank notes and Riksbank notes coexisted from 1831 to 1903. In the United States national bank notes and government notes (Federal Reserve notes) coexisted from 1913 to 1935.

In Canada and the United States, the government notes were introduced to economies that already had private bank notes serving as important, perhaps even the primary, media of exchange. What the Swedish experience adds to our knowledge is that private bank notes can be introduced and become important media of exchange in economies that already have well-established government notes playing that role.

[23]The NDO notes were to be paid out of a government "currency fund" (Wettenberg, 2009, 135).

The Swedish experience further shows that private issuers have to exert effort to get their notes in circulation if there is a well-established government medium of exchange. To get their notes in circulation, Enskilda banks "displayed considerable ingenuity . . . " (Jonung, 2007, 22). One obstacle that Enskilda banks faced was that their notes were not legal tender for the payment of taxes and other government fees. To overcome this obstacle, Enskilda banks "supplied the proper government officials, specifically the tax collectors . . . with suitable funds of *Riksbank* notes and coins to use in exchanging private bank notes for legal tender. . . . Private banks also paid government officials to exchange private notes and to manage the exchange funds" (Jonung, 2007, 18).

Another method that Enskilda banks used to promote their notes was to offer a wide variety of low denominations:

> In the 1840s they [the Enskilda banks] supplied not less than seven denominations between 3 and 15 kronor, while the *Riksbank* had only one denomination is this range. The low denomination notes were also more profitable than the higher denomination notes because the former notes tended to stay out longer in circulation (Jonung, 2007, 19).

As discussed above, the practice of Enskilda banks accepting the notes of other banks at par may also have been a method to help get their notes in circulation. Riksbank notes traded throughout the country. Having Enskilda bank notes generally trade at par would help the notes of individual Enskilda banks compete against Riksbank notes.

6 Lessons for Digital Currencies

Digital currency, defined broadly, is monetary value stored electronically that is accepted as a means of payment. Since the objective of this section is to draw lessons from the experience of bank note issuance in several countries, we focus our discussion on lessons for digital currencies that are neither based on nor require funds in an account, i.e., we focus on token-based, not account-based, digital currencies.[24]

Lesson 1: Digital currencies will not be safe without government intervention.

We first consider digital currencies that are liabilities of the issuer. Economic theory suggests that such currencies will not be safe.[25] The total value of the assets backing such currencies can become less than the total value of the currency issued due to incompetence, malfeasance or simply fluctuations in asset prices. Such occurrences can lead to losses for currency holders if the issuer is not able to redeem them at par if the issuer goes out of business. Such occurrences can also lead to bank suspensions. The experience of Canada, the United States and Sweden supports this theoretical prediction with regard to privately issued currencies that are liabilities of the issuer. The evidence from Sweden also supports the theoretical prediction with regard to government-issued fractionally backed currencies that are liabilities of the government.

[24]For a discussion of different types of digital currencies, see Bech and Garratt (2017), and for a discussion of token-based versus account-based systems, see Kahn (2016).

[25]See, for example, Diamond and Dybvig (1983).

There are several possible ways in which digital currencies that are liabilities of the issuer could be made perfectly safe. For privately issued digital currencies, one way would seem to be giving the holders first lien on the issuer's assets and extending the liability of shareholders. However, the problem with such a solution is that it is not possible to insure that the assets of shareholders always will be large enough to cover the digital currency liability in all states of the world. A case in which assets of shareholders might not be large enough to pay off liabilities might occur if, for example, shareholders are required to sell their assets in a "fire sale."

Another possible way to make safe digital currencies that are liabilities of the issuer would be to require them to be 100 percent backed by perfectly safe assets; e.g., for them to be issued by entities that would be similar to "narrow banks." The problem with such a solution arises if digital currencies are being issued to mitigate some maturity or other asset mismatch friction in the economy. Preventing this friction from being mitigated could cause a welfare loss to the economy.[26]

A third possible way to make safe digital currencies that are liabilities of the issuer would be to have some entity provide insurance or act as a lender of last resort (LOLR). Of course, such an entity would have to have access to resources large enough to cover all of the liabilities of the issuer.[27] Because the resources required are large, it seems unlikely a private entity would be able to fulfill an insurance or LOLR function. Governments, due to their taxation powers, have the ability to command a large quantity of resources. For this reason we state that for digital currencies that are liabilities of the issuer to be safe, government intervention would be required regardless of whether the digital currencies are issued privately or by a government.

Evidence in support of this lesson is given by the U.S. experience with bank notes. Those issued by state banks were not government insured, and they were not safe in all cases. Those issued by national banks, however, were government insured, and they were perfectly safe.

Digital currencies that are not a liability of the issuer or issuers, fiduciary currencies, would seem to be always be safe under our definition because there is no promised redemption. However, theory suggests that such a conclusion would be incorrect. Theory argues that an economy with a fiduciary currency has two potential equilibria: one in which the currency is valued and one in which it is not. Further, an economy can switch from the equilibrium in which the currency is valued to one in which it is not.

Because governments have the power to declare that their currencies must be accepted in certain transactions and for taxes, the non-valued equilibrium can be ruled out for their fiduciary currencies. However, the same is not true for fiduciary digital currencies that are not issued by a government, because the issuers of these digital currencies do not have such powers. There is some evidence that fiduciary digital currencies not issued by a government can disappear and become valueless. Of the 150 tokens with the largest market capitalization

[26] A more complete, theory-based discussion of potential problems with narrow banking is given by Wallace (1996).

[27] We recognize that in many cases the insurer would not have to have access to resources large enough to cover all of the liabilities as the issuers may have some assets that have value even if the issuer has to sell them in fire sale conditions. Further, the presence of insurance or a LOLR may mean that any assets of the issuer can be sold at prices that are closer to normal. Thus, the requirement that the insurance or LOLR entity have resources large enough to cover all liabilities is probably too strong.

at the end of 2015, six had disappeared by November 2016.[28]

Lesson 2: Digital currencies are unlikely to be uniform currency without government intervention.

We consider the currencies of different issuers to be a uniform currency if they trade for each other at the ratios of their stated monetary denominations. Note that implicit in stating the definition of a uniform currency in this way is the assumption that the digital currencies are denominated in the same monetary units, presumably the units of the nation in which they exist. To expand the definition to currencies that are in different monetary units, we modify the definition to be that the currencies trade at a fixed exchange rate.

Consider an economy with multiple currency issuers, all of whom denominate their currencies in the same monetary unit. If there is no mechanism to facilitate that these different currencies circulate at their stated denominations, two equilibria exist for the exchange ratios between the currencies. One is that they trade at their stated denominations; the other is that they do not. We will call this latter case the non-par equilibrium.

In our studies, there are three episodes with private bank notes and two with government notes that fit this description. For private banks, they are the notes issued by banks in Canada before 1890, by state banks in the United States, and by Enskilda banks in Sweden. For government notes, they are Dominion notes in Canada prior to 1881 and the notes issued by the Riksbank and the NDO between 1789 and 1803. In four of these cases, the notes did not trade at their stated denominations at all times and all locations. The one exception when they were a uniform currency was the case of Enskilda notes. From this historical evidence, we conclude that the non-par equilibrium is the more likely outcome in economies without a mechanism to facilitate par trade among currencies.

Our studies also indicate there are mechanisms that can be put in place to make the currencies of different issuers trade at their stated denominations. These mechanisms for the Canada, the United States and Sweden were discussed in Section 5.2. In all cases these mechanisms were established by a government. They did not arise as a private arrangement.

Before concluding that government intervention is necessary to achieve currency uniformity, we must point out that in our studies we have encountered one case of a private system that facilitated par exchange among private bank notes of different issuers and led to uniformity. This was the Suffolk Banking System, which was run by the Suffolk Bank in Boston. The system operated in New England and was a clearing system solely for notes of state banks in that region. Notes of participating banks went at par while the Suffolk Banking System was in operation.

However, despite the existence of the Suffolk Banking System, we think it is unlikely the digital currencies of different issuers will be a uniform currency without some form of government intervention. The Suffolk Banking System was unique. It was not copied. No private clearing systems that could give rise to uniformity arose in other states or regions, even though there were banks in major cities like New York or Philadelphia that could have run systems similar to the Suffolk Banking System as the Suffolk Bank did in Boston.

[28]This calculation is based on information from coinmarketcap.com. We take their designation of a token as "Inactive" as meaning that token has become valueless.

Further, no such private systems arose in Canada.[29]

There is one common characteristic in all of the mechanisms that led to bank notes in Canada and national bank notes in the United States to be exchanged at par. In both cases, the redemption costs in the mechanism were borne by the note issuers rather than the note holders. The reason this characteristic is important is that when the redemption costs are borne by the holder of a note, the potential recipient of a note will discount the note to price in the redemption costs.

In the case of notes issued by Canadian banks, it was the banks that had to bear the cost of maintaining redemption facilities for their notes in the major commercial centers. In the case of notes issued by national banks in the United States, the cost of the redemption facility was allocated to banks based on the quantity of their notes that were presented for redemption. The Suffolk Banking System also had note issuers rather than note holders bear the cost of the redemption. In the Suffolk Banking System, member banks had to maintain a non-interest-bearing deposit of specie with the Suffolk Bank.

The par acceptance system of Enskilda banks also shared this characteristic to some extent:

> The Enskilda banks were willing to bear some discounts costs in order to make their notes closer substitutes for Riksbank notes. In order to assure holders of the convertibility of bank notes into legal tender, the exchange agents were compensated in positive relation to the quantity of the bank's notes that they exchanged for legal tender. Furthermore, in at least some parts of the Country, the Enskilda banks paid a small fee to the municipal tax authorities to act as exchange agents in connection with tax payments. Thus, despite their non-legal tender status, these notes could be used to pay taxes (Ögren, 2003, 159).

Lesson 3: Central bank digital currency will not necessarily drive out existing private digital currency and private digital currency will not necessarily drive out existing central bank digital currency.

In Sweden, the introduction of Enskilda bank notes did not drive out Riksbank notes. Riksbank notes continued to circulate after the Enskilda banks began issuing notes in 1831. However, Figure 12 shows that Enskilda bank notes negatively affected the quantity of Riksbank notes in circulation. This suggests that private digital currency could negatively affect the quantity of central bank digital currency in circulation.

The historical experience in Canada and the United States was similar in that government notes did not drive out existing private bank notes. Canada began issuing provincial notes in 1866, but bank notes, which had been in existence since 1817, continued to circulate until 1 January 1950. The Federal Reserve System in the United States began issuing notes in 1914, but national bank notes, which had first gone into circulation in 1863, continued to circulate.

[29]The Enskilda banks may also be an exception. According to Wetterberg (2009, 197-198) the Stockholms Enskilda Bank *may* have begun to act as a central note clearer around 1857. However, Wetterberg does not say how much clearing the Stockholms Enskilda Bank actually did or how it did it.

There is one problem with drawing lessons about the coexistence of private and government bank notes from the historical experience that does not arise with the previous lessons. It is that bank notes are physical objects. They were (and are) printed on paper. As a result, they must be issued in a finite number of denominations. With historical physical currencies, there were cases in which a currency was considered to be better than others, and was therefore used, because it was issued in "more useful" denominations. In essence, there was a convenience factor or yield supporting the new currency. Improved convenience based on denominations likely will not arise with digital currencies. The number of places to the right of the decimal point is limited only by the capability of computers. Other dimensions could arise that allow one digital currency to differentiate itself from others, to trade off one benefit against another and support the coexistence of government and private currencies.

For instance, a government or central bank can always issue an instrument, be it physical or digital, that will circulate as a medium of exchange. This is due, at least in part, to its ability to declare such an instrument the sole instrument in which taxes can be paid.[30] In addition, technology is such that private digital currencies can carry information beyond just an amount of a currency. Such information could be used to make that currency better for some transactions. In principle, the same information is available for a government digital currency. However, in practice, it may be difficult to utilize this information the same way as a private issuer as it might be seen as showing favoritism to one party over another.[31] Any new currency that aims to be adopted by the population must offer some differentiating factor, some convenience yield, to convince people to accept the new method of payment. Differentiating factors for digital currencies could include security features, whether or not it is risk free, usefulness for a particular type of transaction, accompanying information, use in offline transactions.

One question that the historical experience with bank notes provides no lesson for is this: Can physical and digital forms of an issuer's medium of exchange coexist? To state it in more concrete terms, can a paper dollar and a digital dollar issued by the Bank of Canada coexist as media of exchange, or will the digital Bank of Canada dollar drive out the paper one, or will the digital one not be used? The answer is probably that they can coexist because there will be instances when agents want the paper dollar for anonymity or do not have access to a network to make the digital transactions even though the digital dollar will be more convenient in other transactions.

Lessons when digital currencies have their own monetary units

In all of our studies, the notes of all issuers were denominated in national monetary units. We presented no historical evidence of cases in which there were media of exchange denom-

[30]The Canadian experience with Dominion notes shows that declaring government notes legal tender may not be enough to get them into widespread circulation if private notes are already a well-established medium of exchange. To help get Dominion notes in circulation, the Canadian government prohibited the issuance of small-denomination bank notes.

[31]Another question worth consideration is whether countries should think about expanding the number of digits to the right of the decimal point in their monetary units. Micropayments will become a more important part of economies and unless there is a great deal of inflation, the cent or the öre may be too large for the IoT (Internet of Things). Digital currencies will allow such micropayments far more easily than will physical currencies.

inated in their own individual monetary units. Nonetheless, since private digital currencies with their own monetary units are proliferating, we conclude with some speculation about whether they will be safe, whether they will become a uniform currency and whether they will drive out digital currencies in national monetary units.

With respect to safety, all digital currencies, regardless of the monetary units in which they are denominated, regardless of whether or not they are fiduciary and regardless of whether they are issued privately or by a government, are subject to fraud and cyberattacks. Thus, they will not be safe unless the government intervention insures against such losses.

With respect to uniformity, today there are over 1,350 different digital currencies with their own monetary units. Bitcoin and Ethereum are two well-known examples. Just as was the case with currencies of different issuers with the same monetary units, there are multiple equilibria for currencies of different issuers each with its own monetary unit.[32] In only one of these equilibria is the exchange rate between the currencies constant.

Further, it seems unlikely to us that Bitcoin, Ethereum or another digital currency will act to peg their currencies against another digital currency or against the Canadian dollar, the U.S. dollar, the Swedish kronor or any other national currency. It also seems unlikely that any outside agent would attempt to do such pegging due to costs and risks.[33]

With respect to coexistence, we have no historical evidence of a case in which a new private medium of exchange denominated in a different monetary unit has been successfully introduced to an economy.[34] Bitcoin and Ethereum are two examples of cryptocurrencies that are attempting to do this. It will be interesting to see how well they are able to do it.

[32]For two papers that discuss the multiplicity problem for currencies with their own monetary units see Kareken and Wallace (1981) and King, Wallace, and Weber (1992).

[33]An exception is the digital currency Tether, which is pegging its token 1:1 against the U.S. dollar. However, it has not taken off as a digital currency to this point.

[34]There are examples of governments introducing new media of exchange with monetary units differing from the existing ones. The introduction of the euro is a notable recent example. The euro succeeded because the ratio of the new monetary units to each of the old units was specified in advance and the new currency was supplied to holders of the old at those ratios.

Appendix A: The Swedish monetary system[35]

A.1 1624-1776

During this period, the Swedish monetary system had coins of three metals: copper, silver, and gold. The copper coins were of two types – small denomination ("*slantar*") and larger denomination plates ("*plåtar*"). Silver coins in domestic circulation were also of two types – small denomination ("*courant*") and larger denomination ("*carolins*"). An international silver coin, the *riksdaler*, was also minted as was one international gold coin, the "*ducat*."

Along with these six coins, there were four different units of account. The two for the main currencies were the *daler silvermynt* (d.s.m.), which had 1 *daler* = 4 marks = 32 *öre* and the *daler kopparmynt* (d.k.m.), which also had 1 *daler* = 4 marks = 32 *öre*. The two other units of account that came into existence were the *daler courant* and the *daler carolin*. However, these were not as widely used as the *daler silvermynt* and *daler kopparmynt*. Note that the denomination *daler* appears in all four units of account, although the systems were different: a *daler* in one was not equal to a *daler* in another.

The reason for the two main units of account was that Sweden was on a bimetallic silver and copper standard. The systems started with 1 *daler* d.s.m. = 1 *daler* d.k.m. However, in 1633 the ratio was changed to 1 *daler* d.s.m. = 2 *daler* d.k.m.; in 1643, to 1 *daler* d.s.m. = 2.5 *daler* d.k.m.; and in 1665, to 1 *daler* d.s.m. = 3 *daler* d.k.m. This ratio remained until 1777.

There were other complications with the Swedish system: the units of account were not attached to actual coins and the denomination of coins did not necessarily match their metallic content. As Edvinsson (2012, 411) puts it:

> The *daler koppaarmynt* and *daler silvermynt* together formed a common system of account for the main currency. Even if they were originally meant to differentiate between copper and silver coins, they became abstract units detached from actual coins, i.e. ghost monies. All coins were officially valued by these two units, although de facto a premium was in most periods paid on *riksdaler*, the ducat, and the two current silver coins.... To make it more confusing, ...some petty copper coins were minted in the denomination of *öre silvermynt*, while copper plates were always minted in the denomination of *daler silvermynt*.

Or as Klas Fregert put it in a personal email about the reform in 1665:

> The copper plates were stamped with the unit daler silvermynt such that 1 dale silvermynt (dsm) was set equal to 3 daler kopparmynt (dkm). As the market value of copper to silver changed, the currency unit daler kopparmynt in effect disappeared and the effective currency units became:
>
> - daler silvermynt in copper coins/plates
> - daler silvermynt in silver coins

[35]This section is based heavily on Edvinsson (2012) and a very helpful personal email from Klas Fregert.

Each of these units were equal to 3 daler kopparmynt (in copper or silver coins). Another way to put the change is: 1 daler silvermynt was nothing but the name of 3 daler kopparmynt, not itself a currency unit.

Appendix B: The Goals and Operations of the *Riksens Ständer Bank* and the Riksbank[36]

B.1 Goals

According to Fregert (2012), the paramount goal of the RSB when it was established was to maintain the convertibility of and preserve the value of the currency. He writes, "The preamble of the Charter of 1668 stated that the goal of the Riksbank was to 'preserve the proper and right value of the domestic money and hinder and forestall foreign monies' increase in value'."(Fregert 2012, 4).

Two other goals can be seen from the original organization of the RSB. It was organized along the lines of the Bank of Amsterdam in that it had two departments. One was the loan bank (*Länebanken*), which took deposits and used them to do pure intermediation. The other was the exchange bank (*Växelbanken*), which provided the public with checking services and safe storage of coins. Deposits at the loan bank were interest-bearing; deposits at the exchange bank were non-interest-bearing.

From this structure it can be seen that one of the other goals of the RSB was to intermediate debt and that a second was to provide liquidity to the economy in the form of payment services. This first goal was to be accomplished through the loan bank. The second was to be accomplished through the exchange bank, although how well the exchange bank provided liquidity services is open to question. According to Fregert (2012, 29), "The checking services provided by the exchange bank were exceedingly complicated and time-consuming and appears [sic] to have been used only to a limited extent. . . ." The provision of liquidity services by the exchange bank did not really take place until the use of notes became widespread, beginning in 1726. The RSB was initially prohibited from issuing notes, as discussed in the main text above.

B.2 Operations

The activities of the Riksbank (for the rest of this Appendix, we will use Riksbank to refer to both the RSB and the Riksbank) did not remain the same over time. The Riksbank started out behaving very much like what we would think of today as a private bank, except that it funded a large part of its lending with notes, rather than exclusively through deposits. Over time, however, it took on more of the functions and responsibilities of a central bank engaging in what could be thought of as discount window lending and open market operations. In this section we trace this evolution by looking at the balance sheets of the Riksbank as they changed over time to reflect the changes in the Riksbank's operations.

Our division of this discussion by different time periods is motivated by the timing of changes in the Swedish monetary system's unit of account, which led to changes in the Riksbank's reporting of its assets and liabilities. The result is that our timing is similar to but not identical to that of Fregert (2012).

[36]The data underlying this discussion are from a spreadsheet provided to us in an email by Klas Fregert. This spreadsheet contains a detailed breakdown of the asset and liabilities items on the RSB and Riksbank balance sheet. We are deeply indebted to Klas Fregert for the data.

1668-1776

The early operations of the Riksbank can be seen in Figures B.1 and B.2, which show the assets and liabilities on the balance sheets of the bank from 1668 to 1776, respectively. Although superficially balance sheets might look like those of a central bank operating under a commodity standard, closer examination shows that they look very much like those of a private bank in the United States or Canada in the 1800s.

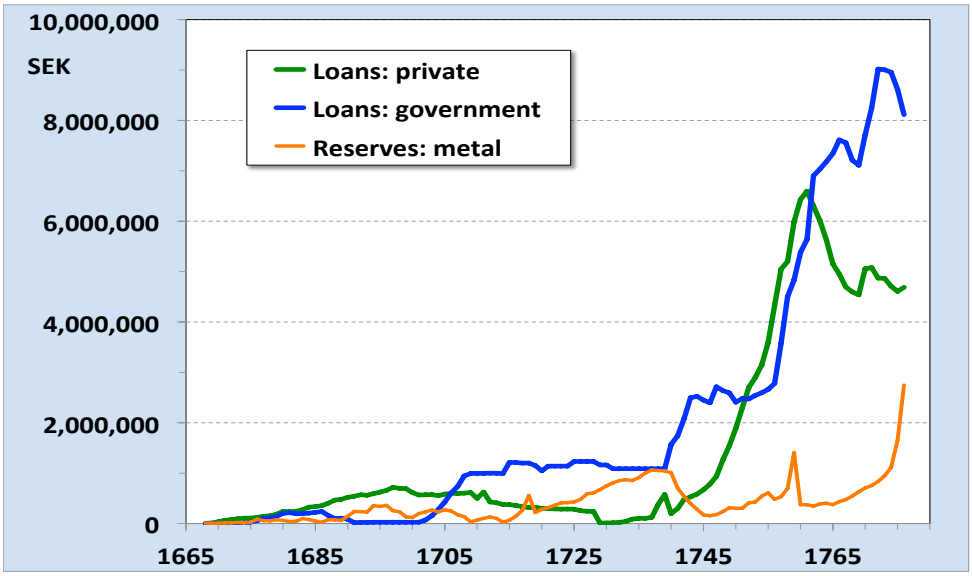

Figure B.1: Riksbank assets, 1668-1776

One reason for thinking these balance sheets could look like those of central bank is that note issuance makes up a large part of the Riksbank's liabilities. However, that was also true of private banks in the 1800s. Also, one might think that the deposits in the Riksbank were similar to bank reserves in central banks. However, there were no other banks in Sweden during this time, which meant that these were deposits of individuals, not banks, just as would be the case for a private bank, but would not be the case for a central bank. As an aside, Riksbank notes are greater than total deposits beginning in 1742.

The asset side of the balance sheet shows even more clearly that the Riksbank acted like a private bank. For one, the bank made direct loans to the nonbank private sector. As Figure B.3 clearly shows, the largest component of "Loans: Private" was "Loans on mortgages (*lån på fasta panter*)." Two other categories of "Loans: Private" were "loans on other pledges (*lån på lösa panter*)" and "loans on loan bank attests (*lån på lånebankoattester*)," and they also represented direct lending to the nonbank private sector. The one component of

[37]The figure begins in 1729 because that is the date at which consistent data become available. The data are in d.s.m. We converted to SEK using the conversion factors in Fregert's spreadsheets.

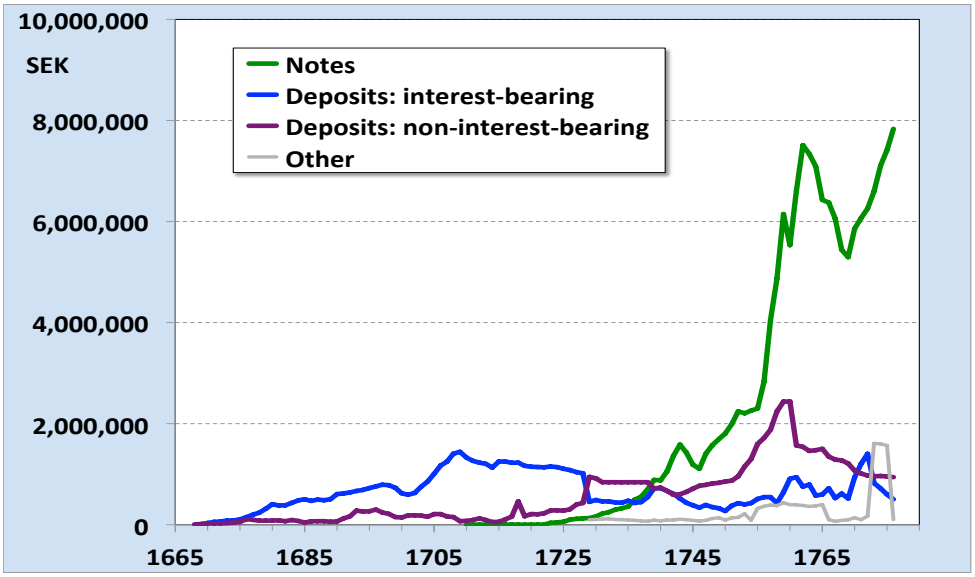

Figure B.2: Riksbank liabilities, 1668-1776

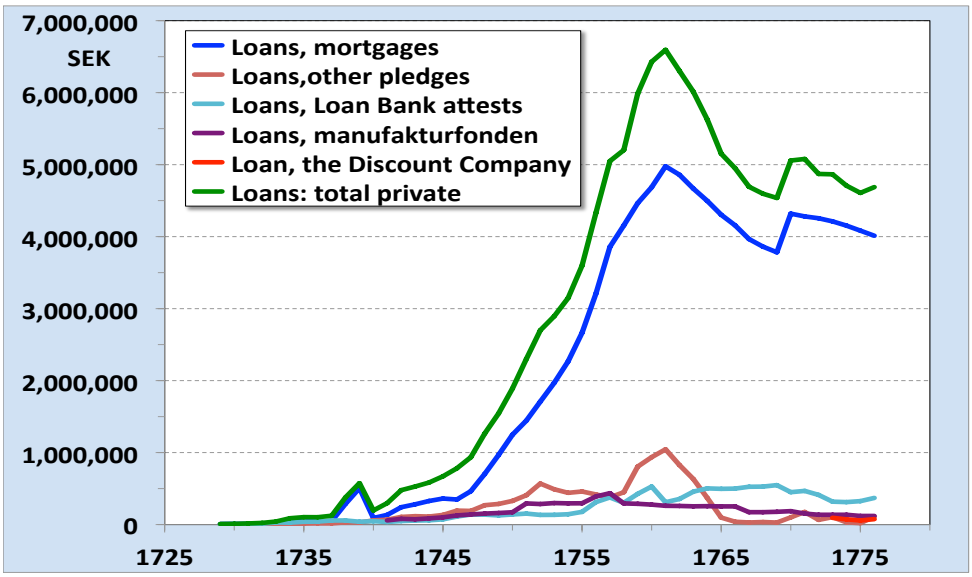

Figure B.3: Riksbank private loans by category, 1729-1776[37]

private loans that might be considered central bank-like is "Loans to manufakturfonden" (*lån till Manufakturkontoret*)." However, rather than being discounted loans against collateral pledged by private financial institutions, which would be the case for a central bank, these loans were, in essence, direct lending to manufacturing. In 1741 the government set up the *Manufakturdiskonten*, a government bank under government authority *Manufakturkontoret*, which made subsidized loans to manufacturing. This balance sheet item is funds given to that authority by the Riksbank.

Another way that the balance sheets show the Riksbank acted like a private bank is the "Loans: Government." These were not purchases of government securities, as they would be for a central bank. Rather they were direct loans to the government to finance wars. The two largest increases were for the Hats' Russian War (1741-1743) and the Seven Years' War (1756-1762).

The increase in metal reserves beginning around 1775 was motivated by the decision to resume convertibility of RSB notes, which occurred in 1777.

B.2 1777-1856

The assets and liabilities on the balance sheets of the Riksbank from 1777 to 1856 are shown in Figures B.4 and B.5, respectively. These figures appear to show that the Riksbank continued to act as a private bank as it had prior to this period. It continued to make loans to the private sector and the government. The only major difference appears to be that the funding for the loans was now heavily from notes rather than deposits.[38] However, a more detailed look at the asset side of the balance sheets shows the beginning of the slow evolution that the Riksbank underwent, going from operating almost exclusively like a private bank to operating like a central bank under a commodity standard.

The evolution in the operations of the Riksbank can be seen in the composition of its loans to the private sector, as shown in Figure B.6. This figure shows the category "Loans, discount companies." Discount companies were private financial institutions that took deposits and made loans, but were prohibited from issuing notes. The first of these was the Discount Company (*Diskontkompaniet*) that was granted a royal charter and began business in 1773. The Riksbank lent to the Discount Company from the start as can be seen in the item "Loan, the Discount Company" in Figure B.3. This item first appears on the balance sheets in 1773. Other discount companies were formed in the early 1800s.[39] The designation of this category was changed from "the Discount Company" to "discount companies" for this reason. So, at least from 1773 to 1817, the Riksbank acted as a lender to other financial institutions, much as a central bank would.

We cannot be sure how involved the Riksbank was with other financial institutions from 1817 until 1856. The reason is that all the private discount companies failed in 1817 (Fregert (2014)) and the Riksbank did not separate out loans to Enskilda banks or joint-stock banks until 1978.[40]

[38]The increase in "Other liabilities" from 1802 to 1816 was due to the Riksbank taking over the obligations of the NDO.

[39]One was formed in Göteborg in 1802 and a second in Malmö in 1803. See Wetterberg (2009, 1420.

[40]The loans to discount companies category that continues on the Riksbank's books after 1817 and are large until 1873, when the category disappears, appears to be loans to an off-balance sheet entity of the Riksbank. According to a private email from Klas Fregert, "From 1803 there was a new discount company

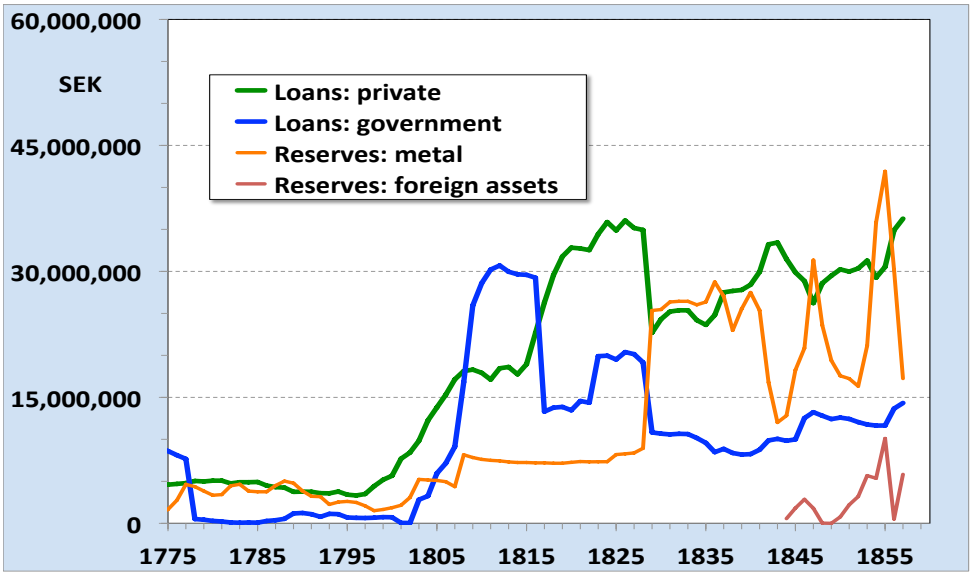

Figure B.4: Riksbank assets, 1777-1857

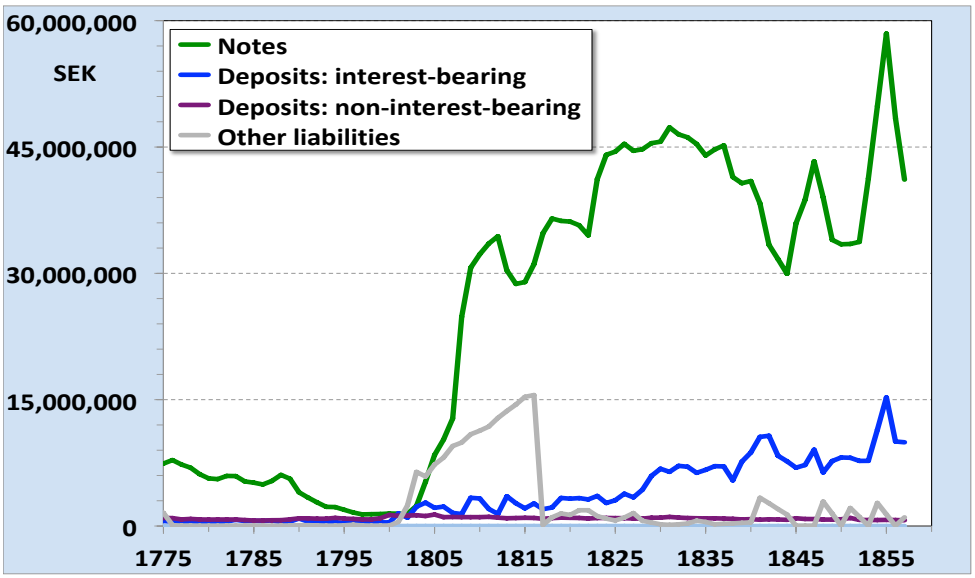

Figure B.5: Riksbank liabilities, 1777-1857

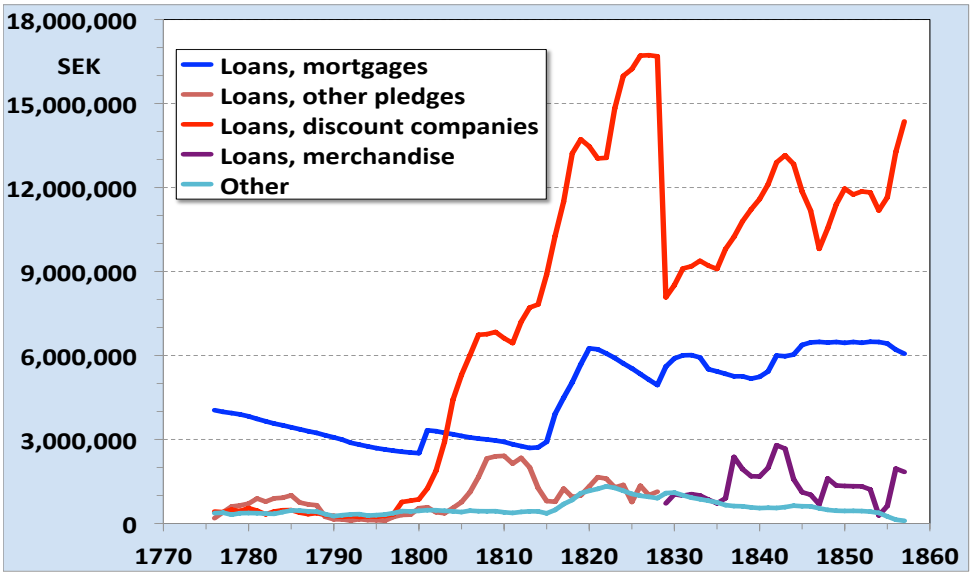

Figure B.6: Riksbank loans to the private sector by category, 1777-1857

B.3 1873-1914

The assets and liabilities on the balance sheets of the Riksbank from 1858 to 1914 are shown in Figures B.7 and B.8, respectively, and a breakdown of the private loans on the asset side of the balance sheet is shown in Figure B.9. The final stages of the evolution of the Riksbank from private bank to central bank are shown in the figures that include the Riksbank's assets. Specifically:

(i) "Loans, government" no longer appears on the asset side of the balance sheet. Instead of making direct loans to the government as before, the Riksbank changed to buying government securities that were traded in the market, which is the practice of today's central banks.

(ii) The Riksbank also began to purchase foreign securities. These are a large component of "Reserves: foreign assets." The purpose was to enable the Riksbank to more easily intervene in foreign exchange markets.

(iii) Direct loans to the private sector have become a smaller part of the asset side of the balance sheet. The fall-off in mortgages is an example of this. Instead, the Riksbank's

called *Riksdiskonten*, which was formed from two state-owned discount companies: *Manufakturdiskonten* and *Riksgäldsdiskonten*. The new *Riksgäldsdiskonten* was half-owned by the government and half-owned by private shareholders. It became wholly owned by the Riksbank in 1815. It became *Handels och näringsdiskonten* in 1830, which was formally separated from the Riksbank until 1872, but in reality part of Riksbanken since 1815."

assets consist in large part of "Bills, payable in Sweden," indicating that their business consisted of running a discount window as do today's central banks.

Other developments, not shown in the balance sheets because lending to banks was not separately broken out, was that the Riksbank lent to private banks in the crisis of 1878.[41]

> A deeper crisis [deeper than the crisis of 1873-1874] occurred in 1878. This is the first time the Riksbank actively lent to private banks to avoid a deeper depression through credit contraction and marks the beginning of the Riksbank as a modern central bank Fregert (2012, 86).

Further, the Riksbank extended discounting rights to Enskilda banks and joint-stock banks in 1893.

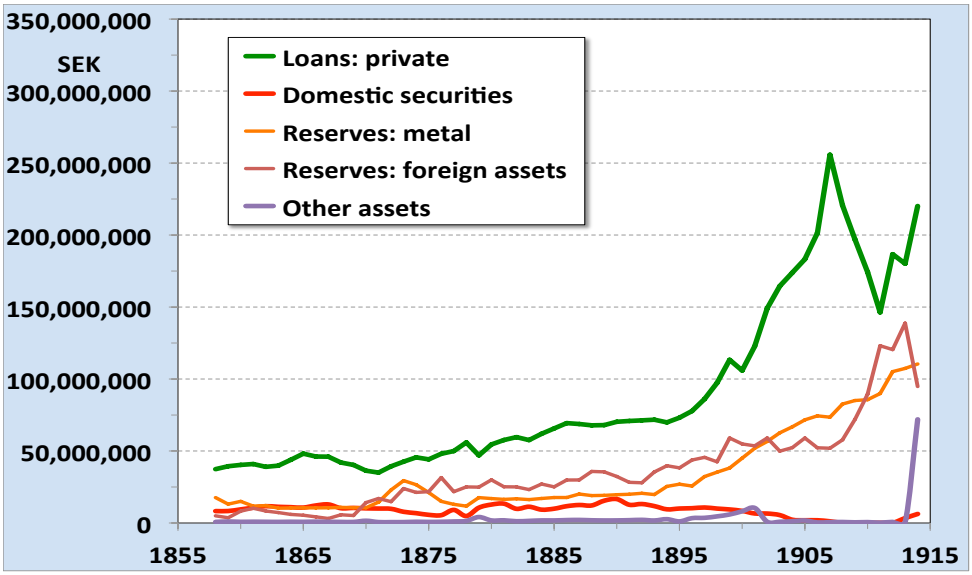

Figure B.7: Riksbank assets, 1858-1914

[41]The "Credit to private banks" shown in Figure B.9 is a special credit given to note-issuing Enskilda banks when the Riksbank was given a monopoly in 1903.

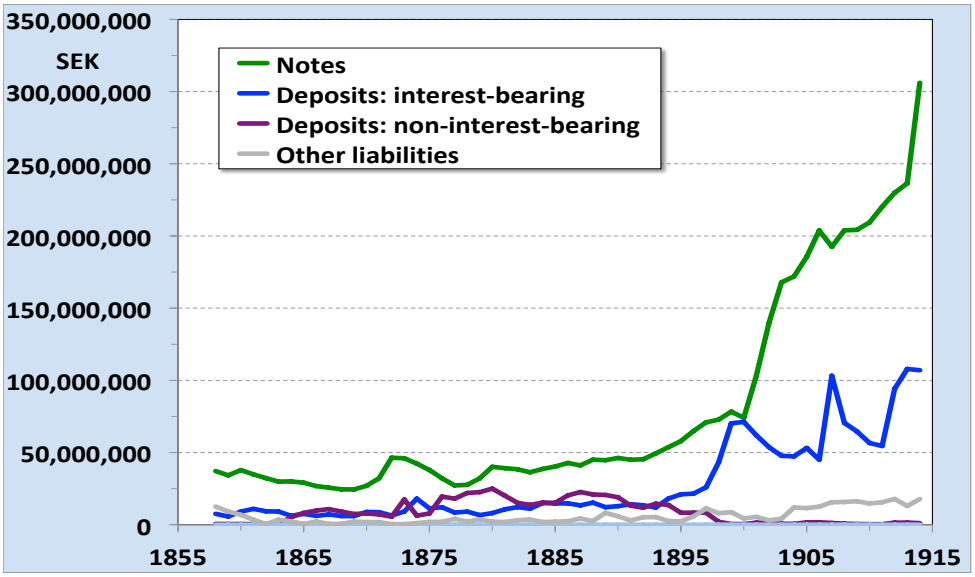

Figure B.8: Riksbank liabilities, 1858-1914

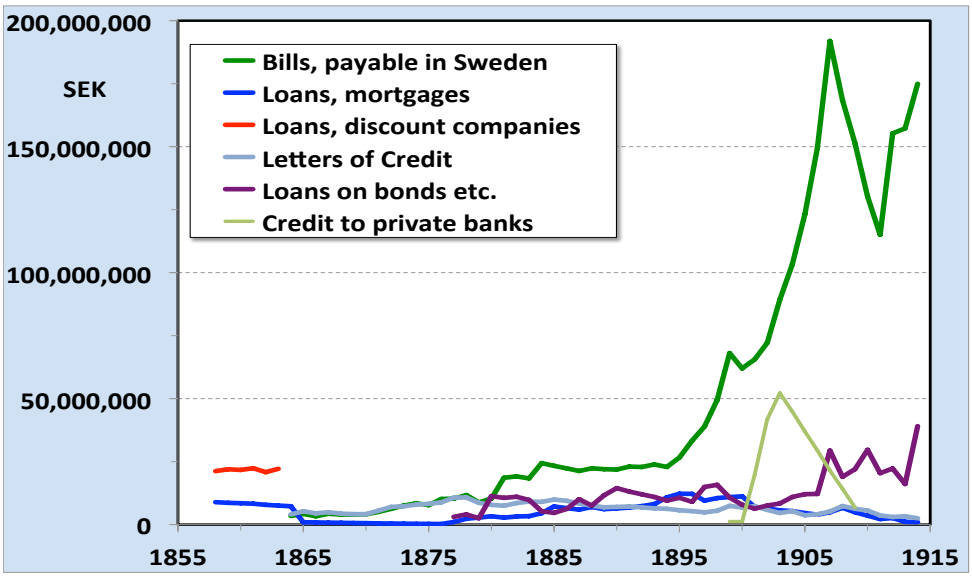

Figure B.9: Riksbank loans to the private sector by category, 1858-1914

References

Bech, M., and R. Garratt (2017): "Central Bank Cryptocurrencies," *BIS Quarterly Review*, pp. 55–70.

Diamond, D. W., and P. H. Dybvig (1983): "Bank Runs, Deposit Insurance, and Liquidity," *The Journal of Political Economy*, pp. 401–419.

Edvinsson, R. (2010a): "Foreign Exchange Rates in Sweden, 1658-1803," in *Historical Monetary and Financial Statistics for Sweden: Exchange Rates, Prices, and Wages, 1277-2008*, ed. by R. Edvinsson, T. Jacobson, and D. Walderström, pp. 238–290. Ekerlids Forlag, Stockholm.

——— (2010b): "The Multiple Currencies of Sweden-Finland, 1534-1803," in *Historical Monetary and Financial Statistics for Sweden: Exchange Rates, Prices, and Wages, 1277 - 2008*, ed. by R. Edvinsson, T. Jacobson, and D. Walderström, pp. 134–237. Ekerlids Forlag, Stockholm.

——— (2010c): "Swedish Monetary Standards in a Historical Perspective," in *Historical Monetary and Financial Statistics for Sweden: Exchange Rates, Prices, and Wages, 1277-2008*, ed. by R. Edvinsson, T. Jacobson, and D. Walderström, pp. 26–66. Ekerlids Forlag, Stockholm.

——— (2012): "Early Modern Copper Money: Multiple Currencies and Trimetallism in Sweden, 1624-1776," *European Review of Economic History*, pp. 408–429.

Edvinsson, R., and A. Ögren (2014): "Swedish Money Supply, 1620-2012," in *Historical Monetary and Financial Statistics for Sweden, Volume II: House Prices, Stock Returns, National Accounts, and the Riksbank Balance, 1620-2012*, ed. by R. Edvinsson, T. Jacobson, and D. Walderström, pp. 293–338. TMG, Stockholm.

Engdahl, T., and A. Ögren (2008): "Multiple Paper Monies in Sweden 1789-1903: Substitution or Complementarity?," *Financial History Review*, pp. 73–91.

Fregert, K. (2012): "The Swedish Riksbank 1668-2010; A View from Its Balance Sheet," Department of Economics, Lund University.

——— (2014): "The Riksbank Balance Sheet, 1668-2011," in *Historical Monetary and Financial Statistics for Sweden, Volume II: House Prices, Stock Returns, National Accounts, and the Riksbank Balance, 1620-2012*, ed. by R. Edvinsson, T. Jacobson, and D. Walderström, pp. 339–393. TMG, Stockholm.

Fung, B., S. Hendry, and W. E. Weber (2017): "Canadian Bank Notes and Dominion Notes: Lessons for Digital Currencies," Bank of Canada Staff Working Paper 2017-5.

Heckscher, E. F. (1934): "The Bank of Sweden in its Connection with the Bank of Amsterdam," in *History of the Principal Public Banks*, ed. by J. G. Van Dillen, pp. 161–199. Martinus Nijhoff, The Hague.

Jonung, L. (2007): "The Economics of Private Money: Private Bank Notes in Sweden, 1831-1902," unpublished.

Kahn, C. M. (2016): "How are Payment Accounts Special?," Payments Innovation Symposium Federal Reserve Bank of Chicago.

Kareken, J., and N. Wallace (1981): "On the Indeterminacy of Equilibrium Exchange Rates," *Quarterly Journal of Economics*, pp. 207–222.

King, R. G., N. Wallace, and W. E. Weber (1992): "Nonfundamental Uncertainty and Exchange Rates," *International Economic Review*, pp. 83–108.

Ögren, A. (2003): *Empirical Studies in Money, Credit and Banking: The Swedish Credit Market in Transition under the Silver and Gold Standards, 1834-1913*. Stockholm School of Economics, Stockholm.

Wallace, N. (1996): "Narrow Banking Meets the Diamond-Dybvig Model," *Federal Reserve Bank of Minneapolis Quarterly Review*, pp. 3–13.

Weber, W. E. (2014): "The Efficiency of Private E-Money-Like Systems: The U.S. Experience with State Bank Notes," Bank of Canada Working Paper No. 2014-15.

——— (2015a): "The Efficiency of Private E-Money-Like Systems: The U.S. Experience with National Bank Notes," Bank of Canada Working Paper No. 2015-3.

——— (2015b): "Government and Private E-Money-Like Systems: Federal Reserve Notes and National Bank Notes," Bank of Canada Working Paper No. 2015-8.

Wetterberg, G. (2009): *Money and Power: From Stockholms Banco 1656 to Sveriges Riksbank Today*. Sveriges Riksbank, Stockholm.