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Reserves, Money Supply and Prices: The International Adjustment Mechanism in Sweden under the Silver and Gold Standards, 1834 – 1913

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ABSTRACT

This paper explores how international capital movements affected the domestic money supply. This requires that the causality at work in the adjustment process be analyzed. For this purpose, series of central bank reserves, the monetary base, the money supply and the balance of payments were constructed. The methodological problems encountered in estimating such monetary measures in a transitional economy where much of the circulating money consists of private banks notes, and which is dependent on foreign loans, is discussed. The relationship between central bank (Riksbank) reserves and international capital flows is then studied. The overall growth of the money supply, while not accompanied by a growth in reserves, is found to correspond to such growth in other countries operating under a specie standard. This growth also was related to the growth of the real economy. Qualitative evidence aside, statistical results indicate a relationship among reserves, the money supply and prices that is consistent with the price specie flow mechanism. Changes in reserves were positively related to the money supply and changes in the money supply had a lagged positive effect on changes in the level of consumer prices.

JEL: E31; E51; N13; N23

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Introduction

The Swedish central bank, the Riksbank, together with the private note issuing banks, the so called Enskilda banks, circulated notes exchangeable at par. These notes could be used to make deposits throughout the banking system, and they were backed by the Riksbank's reserves. This arrangement, whereby the Enskilda banks backed their note issuance with holdings of Riksbank notes, allowed Sweden to maintain more currency in circulation, denoted as M1, than otherwise would have possible.[1]

From the readoption of the silver standard in 1834 until the outbreak of World War I, Sweden experienced an unbroken period of eighty years with a fixed exchange rate system. The specie standard as such was of basic importance to Swedish economic

[1] See Ögren, A. (2003c)

growth.[2] The two questions addressed in this paper are if and how the Swedish money supply was affected by international capital flows, and what were the consequences of changes in that money supply.

One particular aspect of the specie standard is its role as an international adjustment mechanism with a fixed world supply of high powered money, whether gold or silver, serving as reserves and the basis for note issuance. The notion of a fixed stock of reserves has been used as the basis for explaining the functioning of the economic adjustment mechanism among countries. The channelling of these reserves from one country to another served to transfer purchasing power.

There are two theories of how the adjustment mechanism functioned. Although related, they have very different implications for the causality at work. According to the price specie flow model, the money supply is determined by the balance of payments through changes in central bank reserves which, in accord with the quantity theory of money, then affects the domestic price level. Finally, changes in the price level will encourage or discourage exports, thereby correcting imbalances in the current account. The monetary ”rules of the game” often related to the working of the classical gold standard, called for this process to be allowed to proceed, or even to be accelerated by using monetary policy to amplify the effects of the capital flows.[3]

The alternative, related but causally different, theory is the monetary approach to the balance of payments. In its purest form, the monetary approach to the balance of payments assumes the law of one price, perfect international capital mobility and price flexibility in all markets.[4] Changes in central bank reserves, however, illustrate that the money market is not in equilibrium, the balance of payments being one of the mechanisms for restoring such equilibrium. The causality is the opposite of that in the specie flow mechanism. Increased (decreased) demand for money eventually will lead to an inflow (outflow) of reserves. Monetary policy has little or no effect. As with prices, domestic interest rates and money incomes ultimately are set in the global arena.[5]

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[2] The conversion from silver to gold in 1873 was an uneventful adaptation to the European economic reality of the time. According to Eichengreen and Flandreau, a country’s adherence to a convertible specie standard was more important for economic growth than was the choice between gold and silver (Eichengreen, B. & Flandreau, M. (1994) pp. 2-3, 6-8).

[3] Bloomfield, A.I. (1978) pp. 47-49, Bordo, M.D. (1984) pp. 25-26, Gomes, L. (1993) pp. 18-21

[4] Although McCloskey & Zecher argues that the monetary approach can do without the law of one price (McCloskey, D.N. & Zecher, J.R. (1984) p. 122)

[5] Gomes, L. (1993) pp. 10, 148, 160, 163-166, Kenwood, A.G. & Loughheed, A.L. (1999) pp. 114-115, McCloskey, D.N. & Zecher, J.R. (1984) p. 126, McCloskey, D.N. & Zecher, J.R. (1985) pp. 65-66, 76

No student of the determinants of the Swedish money supply can fail to be inspired by the work of Lars Jonung. His book, ” Studies in the Monetary History of Sweden” (1975), utilizes the theoretical framework of the quantity theory as developed by Friedman and Schwartz for the United States in their classic work ” A Monetary History of the United States”. Briefly put, Jonung argues that in Sweden the money supply and the stock of gold reserves grew in parallel, and that the money stock appears to have impacted prices both in the long and in the short run, thus lending support to the quantity theory of money.[6] In 1984, Jonung published a paper entitled ”Swedish Experience under the Classical Gold Standard, 1873-1914". In it he argued that the Swedish experience under the classical gold standard fit well within the monetary approach to the balance of payments.[7]

Nowhere in this work, however, does Jonung test the direction of the causality at work. Thus he leaves it unclear whether changes in reserves preceded changes in the money supply, as implied by the quantity theory, or vice versa. He also presents no test of whether or not the monetary base and the money multiplier were related to the money supply. These questions are addressed in this paper, starting with the re-adoption of the silver standard in 1834. An additional advantage of the work presented here is that it is based on revised, more accurate, estimates of central bank reserves, the monetary base and the money supply.[8]

This paper is divided into four sections. The first of these contains estimates of the monetary measures, as well as a methodological discussion of the problems of defining these concepts in a consistent manner. The second section focuses on the reserves of the Swedish central bank, the Riksbank, and how the Bank managed the classical specie standard, as well as the impact of foreign debt. It ends with an attempt to measure the degree of monetary discipline practiced under the silver and gold standards. Next, in the third section the growth of the money supply is examined in relation to the fixed exchange rate regime. Finally, the fourth section concerns the causality among changes in reserves, the money supply and prices. On the assumption that these causal

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[6] Jonung, L. (1975) pp. 144-146, 191-195, 203, 208-211. Under the silver standard, the money stock grew with 16.1 percent every year, in contrast to prices that only grew with 1 percent. Under the gold standard 1874-1913 the money stock increased with 5.2 percent yearly and prices with only 0.2 percent.

[7] Jonung, L. (1984) pp. 389-393.

[8] See also Ögren, A. (2003c)

relationships were complex and movements in the variables interrelated, Vector Auto Regressions were utilized.[9]

The Theoretical Framework and Monetary Definitions

In orthodox economic theory, three sets of actors determine the domestic money supply in a fractional reserve banking system: 1) the monetary authorities, 2) the banking sector, and 3) the public. Under a fixed exchange rate regime, the ability of the monetary authorities to alter the money supply is constrained by their need to maintain reserves. These, in turn are affected by the balance of payments. The theoretical relation between the domestic money supply and its determinants are summarized in five equations:

(1) $M = C + D$; where M denotes the money supply, C the public's holding of currency and D the public's deposits in the banking system.

(2) $B = C + R$; where B is base money, usually defined as the monetary liabilities of the authorities. These liabilities are balanced by a corresponding amount of assets that actually, or potentially, can by used as reserves by the banking system. The R denotes reserves held by the banking system.

(3) $r = R / D$; r is the reserve to deposits ratio of the banks. It is through this mechanism, being part of the money multiplier, that the banking system affects the size of the money supply.

(4) $c = C / M$; c is the currency to money ratio. It measures the public's desire to hold currency. It is through this part of the money multiplier that the public's preferences affect the money supply.

(5) $M = B / (c + r – cr)$; this is the equation that relates the supply of base money (B), through the money multiplier $(1/(c+r-cr))$, to the total money supply M. This last equation is often written as $M = mB$; where m denotes the multiplier.

Two serious concerns arise when making this theoretical framework operational for purposes of research: 1) Equations 1 and 2 together indicate that currency not consisting of the public's deposits, by definition, has to be base money. Conversely, all liabilities held by the public that are not issued by the monetary authorities must be deposits, and

[9] The VAR test differs from the Granger test in that it besides form including several independent variables, also includes values of the dependent values from prior periods. Still, as is the case with the Granger causality, its predictive power is based on precedence and not actual causality, which of course is impossible to prove in a statistical test.

2) Consequently, the outcome of the research is to a large degree dependent on what these monetary components actually consist of.

In Jonung's work, the money supply was defined as the public's holdings of Riksbank and Enskilda bank notes, plus their deposits in commercial banks. The monetary base consisted of the sum of 1) the Riksbank note holdings of the public and the commercial banks, 2) the specie holdings of the commercial banks and 3) the deposits of the commercial banks with the Riksbank and the National Debt Office.[10]

The Monetary Base

In this section, the quantity of base money and the balance of payments are estimated utilizing the approach of Jonung (1975) for Sweden and of Officer (2002) for the United States. The definition of the monetary base is straightforward: It consists of those assets that actually, or potentially, could be used as reserves by the commercial banking system. It is closely related to the balance of payments, any imbalance in which constitutes the effects of international transactions on the monetary base.[11]

This general definition of the monetary base, however, does not make the measurement of its components a simple task. Still, three types of assets can arguably be said to have constituted the Swedish monetary base under the classical specie standard: specie, the net foreign assets of the Riksbank and Riksbank notes.[12]

Throughout this period, specie was the principal ingredient of the Riksbank's reserves. It was also utilized by the Enskilda banks after the implementation of the Banking Act of 1874. Indeed, this legislation required that the Enskilda bank notes be redeemable in specie even though these notes did not receive legal tender status. It could be argued that the Enskilda bank notes should be counted as part of the monetary base starting in 1874, but in fact the commercial banks only held such notes to a minor extent. While it might have been felt that holding the liabilities of other commercial banks tended to give the issuing bank a competitive advantage, the principal reason was

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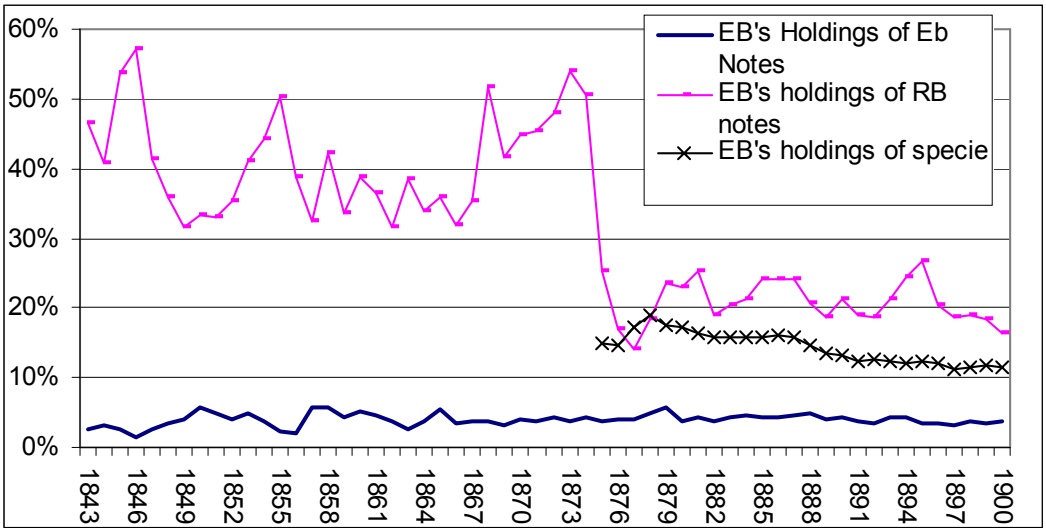
[10] Jonung, L. (1975) pp. 13, 29, 208-215. Jonung did not discuss the problem of how to characterize the Enskilda bank notes, as part of the public's preference for holding currency or part of the public's deposits in the banking system. He included Enskilda bank notes in the money stock as part of the public's holdings of notes when defining the measure, but did include it in commercial bank deposits when calculating the currency money ratio (Jonung, L. (1975) p. 13, 54, 71, 78, 215).

[11] Officer, L.H. (2002) pp. 114-115, 119

[12] Officer, L.H. (2002) p. 127. The Treasury in Sweden, the National Debt Office, only issued notes between 1789 and 1818. Instead the NDO raised capital by issuing bonds from the late 1850s. This was mainly done in the capital markets of Frankfurt am Main, Hamburg, London and Paris (see Ögren, A. (2003b).

probably the public's preference for access to legal tender. Quantitative evidence supports the contention that specie and Riksbank notes, but not Enskilda bank notes, served as potential commercial bank reserves.

Figure 1: The Enskilda banks' Holdings of Specie, Riksbank and other Enskilda bank Notes in a Percentage of Issued Enskilda bank Notes, 1843-1900



Sources: Post & Inrikes Tidning, 1844-1871, Sammandrag af Bankernas Uppgifter 1871-1900

Figure 1 indicates that the Enskilda banks preferred to hold Riksbank notes rather than the notes of other Enskilda banks. Despite the 1897 decision that all the Enskilda bank notes were to be withdrawn from circulation by 1906, the holdings of these notes was unchanged as late as 1903. Clearly these notes were held in anticipation of an opportunity to redeem them. The specie holdings recorded starting in 1874, was obviously at the expense of Riksbank notes. The Enskilda banks were simply exchanging Riksbank notes for specie to the extent legally required.[13]

Thus, in a nutshell, even though the Enskilda bank notes could be used for deposits in other banks, starting in 1869 even in the Riksbank, these notes did not satisfy the requirements for serving as potential reserves for the commercial banking system. This remained the case even after they were made redeemable in specie in 1874.

Notes issued by the central bank, however, served as potential reserves for the banking system. Indeed, Riksbank liabilities other than notes formally contributed to the money stock. These included demand deposits, cheques, postal bank bills and, until 1872, a fund dedicated to certain types of loans. Deposits in the Riksbank were used as

[13] See Ögren, A. (2003c)

bank reserves, including as backing for Enskilda bank notes. Riksbank cheques and postal bank bills circulated just like notes and were backed by specie.[14] The unutilized part of the loan fund specifically dedicated to certain types of loans, which was of considerable size by its ending in 1872, should be deducted from the monetary base.

Foreign assets of the Riksbank utilized as backing for note issuance included holdings in banks and banking firms abroad, as well as foreign treasury bonds. Starting with the crisis of 1857/58, foreign bills of exchange became part of the reserves, even thought this practice had originated as a way of circumventing the demands of the specie standard. One reason it was abandoned in 1872 was that commercial banks held bank credits abroad and then had the Riksbank discount bills drawn on these credits. Ending the inclusion of these bills in the formal reserves of the Riksbank, however, did not end the discounting of such bills. Indeed, the Riksbank holdings of such bills increased throughout the period. Since the Riksbank used foreign bills of exchange to influence the exchange rate through open market operations, these bills should be included in the monetary base.[15]

One difficulty with the Swedish case is the absence of data on the circulation of coins, including specie. Since contemporary sources complain about the shortage coins, I have accepted the assumption of prior works that this circulation was insignificant. Between 1834 and 1843, Riksbank notes circulating in Finland also should be deducted from the Swedish monetary base.[16] Thus, the net contribution of the Riksbank to the monetary base was its issue of money, minus the sum of: 1) its notes circulating abroad, 2) the "dedicated" loan fund, 3) its holdings of specie, and 4) its net foreign assets.[17]

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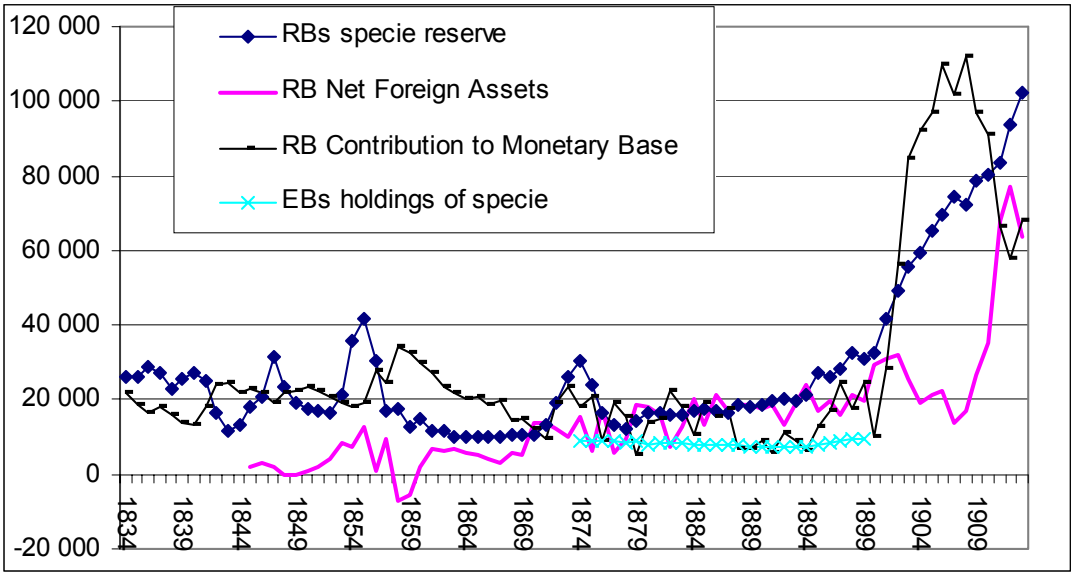
[14] Sveriges Riksbank (1931) pp. 18-31, 54-71. Regarding so called postnotes in the US, see Officer L.H. (2002) pp. 123-124.

[15] See Ögren, A. (2003b). Regarding the active use of the bills of exchange to stabilize the exchange rate of the Swedish currency, see Lobell (2000), and about the commercial banks use of foreign credits see Söderlund, E. (1964). The locked loan fund was abandoned at the same time as bills of exchange were banned from being used as reserves in 1872, as part of the modernization of the Riksbank (see Brisman, S. (1931)).

[16] This was made by assuming that the entire trade deficit towards Finland was paid in Riksbank notes from 1834 until 1840, and then using Davidsson's figures for repayments. This means that 3 million SEK was already circulating in Finland at the beginning of the period. See Davidsson, D. (1931:1) pp. 205-517

[17] This is one way of specifying how the monetary authorities adds to the stock of base money.

Figure 2: Components of the Monetary Base, 1834-1913, (1000's SEK)



Sources: Davidsson, D. (1931:1) pp. 205, 211, Sammandrag af Bankernas Uppgifter 1874-1900, Sveriges Riksbank (1931) pp. 18-31, 54-71

As figure 2 indicates, the monetary base was fairly stable until it took off during the closing years of the nineteenth century. Both specie reserves and the Bank's contribution to the monetary base, started to increase rapidly during the late 1890s. This was only partly a result of the cessation of Enskilda bank note issuance.[18] The specie part of the monetary base mainly increased during the booms of the 1850s and the 1870s.

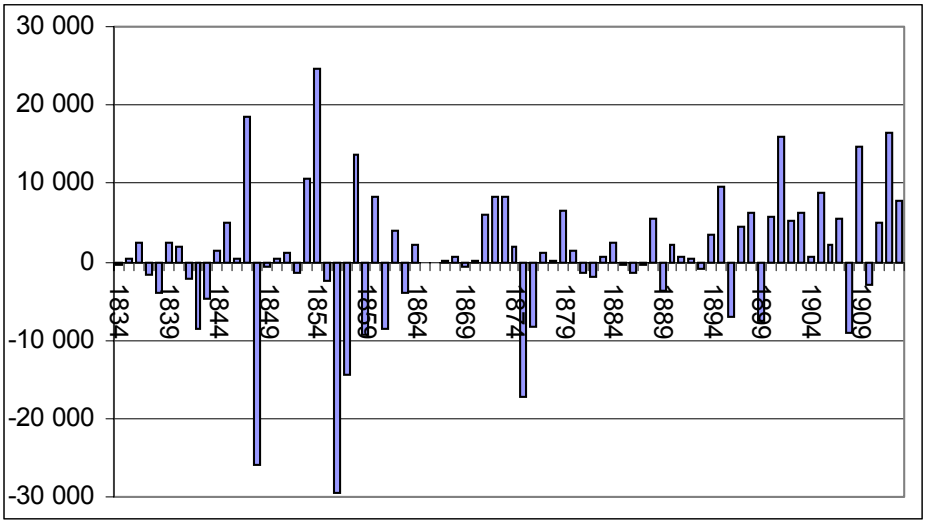
The Monetary Balance of Payments

The monetary balance of payments is closely linked to the monetary base. Indeed, the most direct way to view the balance of payments is as changes in central bank reserves. The monetary balance of payments is defined as net specie imports plus the change in net foreign assets held by the authorities. Thus it is the sum of all international transactions that affect the size of the monetary base. The balance of payments series for the United States estimated by Officer includes net changes in the foreign holdings of both the Treasury and the central bank.[19]

[18] Ögren, A. (2003c)

[19] Officer, L.H. (2002) pp. 132-133

Figure 3: Annual Monetary Balance of Payments, 1834-1913 (1000's SEK)



Source: Sveriges Riksbank (1931) pp. 18-31, 54-71

In Figure 3 above, the balance of payments consists of changes in the Riksbank's specie and its net foreign holdings. Capital flows related to the foreign liabilities of the National Debt Office are not included. Thus this series does not include the current account deficits financed by the importation of capital. A further discussion of the relationship of the foreign debt to the monetary base and the balance of payments now follows.

Methodological Problems of Estimating the Monetary Base

It should now be apparent that the concepts of monetary base and the balance of payments are not problem free. Two principal difficulties arise: 1) what constitutes potential commercial bank reserves, and 2) what is to be included among the net foreign assets of the authorities?

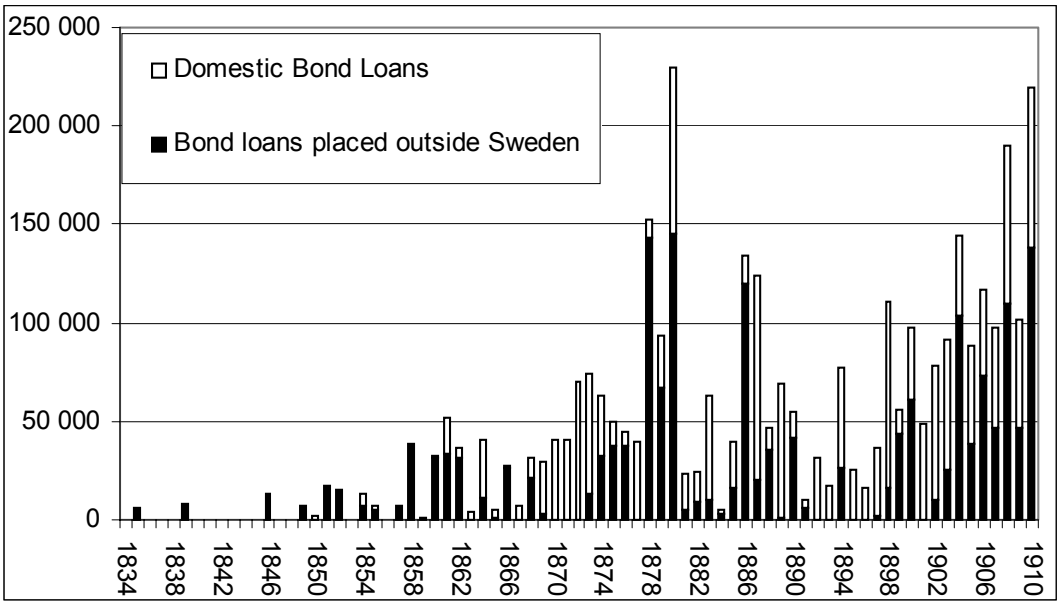
As highlighted by the discussion of how to classify Enskilda bank notes, the definition of potential banking reserves is plagued by the problem of evaluating the liabilities of domestic financial actors. One aspect of the monetary base is that it is provided by so-called outside agents. Thus, its size can be altered only through international transactions and the domestic production of specie.[20] Thus, domestic financial assets and liabilities, other than notes issued by the central bank, should not be considered part of the monetary base.[21]

[20] Officer, L.H. (2002) p. 119

[21] This is not at all self evident. One argument may be that the notes were redeemable for specie, but so were notes issued by Enskilda banks after 1874.

Nonetheless, the Swedish banks were allowed to use bonds issued by the National Debt Office, local governments and mortgage associations both as part of their equity capital and as legal backing for their notes.[22] If such financial assets were to be included in the monetary base, it would increase in step with the domestic demand for credit.

Figure 4: Swedish Domestic and International Bond Loans, 1834 – 1910



Source: Flodström, I. (1912) pp. 812-815

Figure 4 demonstrates that the level of outstanding bond loans, both foreign and domestic, was substantial. In addition to the problem of categorizing the domestic bond holdings of the commercial banks as arguably being utilized as reserves, there is the problem of deciding which types of net foreign assets held by the authorities should be included in the monetary base. The National Debt Office placed its bonds on the international capital market. In the case of the Unites States, Officer concluded that the contribution of net foreign assets to the monetary base was of little importance.[23] For Sweden, a small, open, capital importing economy, however, this certainly was not the case.

In particular the foreign borrowing of the National Debt Office brought this question to the fore. Officer included the net foreign assets of the central bank and Treasury

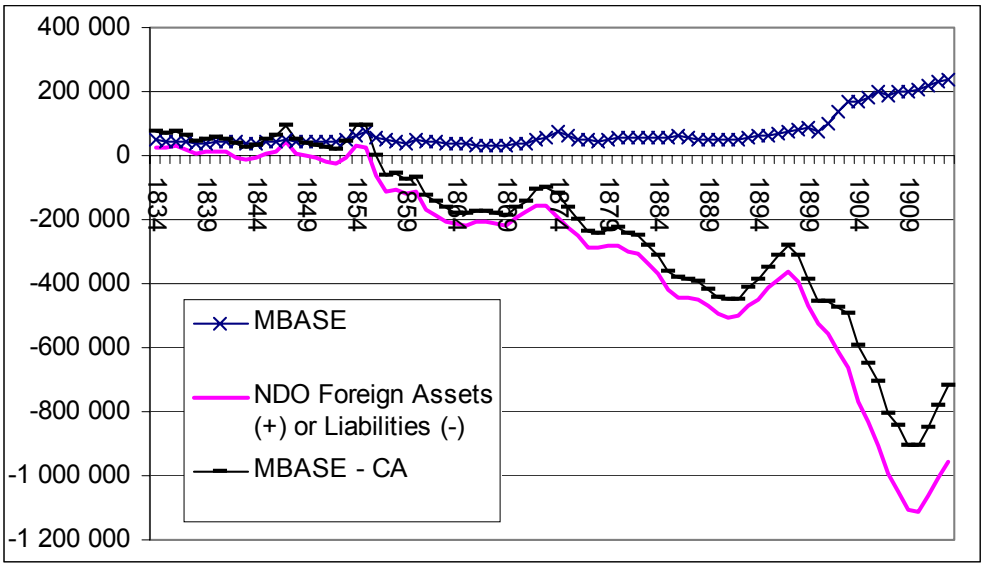
[22] It should also be noted, that legal reserve requirements for Enskilda banks concerned backing of notes, and not any other liability (Ögren, A. (2003c). For joint stock banks, without the right to issue notes, a minimum size of equity capital was specified. Furthermore, Jonung included some liabilities of the National Debt Office in the monetary base, namely the commercial banks' deposits in this authority (Jonung, L. (1975) p. 29).

[23] Officer, L.H. (2002) p. 128

currency held by foreigners in the US monetary base.[24] On that basis, it is unclear why the foreign liabilities of the National Debt Office should be excluded from the Swedish monetary base. Granted, the bonds issued by the Office were long term and neither the Office or the Riksbank guaranteed their instant convertibility into currency. Even so, had they been issued directly by the Riksbank on behalf of the State, instead of the National Debt Office, they would have been included.

Consequently, the net foreign assets component of the monetary base has been calculated in two alternative ways: with and without the foreign liabilities of the National Debt Office, the principal capital importer. If it is assumed that the Office's foreign borrowing equaled that part of the current account deficit not covered by changes in the reserves, or non-reserve foreign assets, of the Riksbank, then the foreign liabilities of the Office can be calculated as the annual difference between the current account and the reserves, minus the non-reserve financial assets of the Riksbank. To convert this into a measure of net foreign assets, this series has been summed over the period.

Figure 5: The Monetary Base Including (MBASE-CA) and Excluding (MBASE) Net Foreign Assets of the National Debt Office, 1834-1913 (1000's SEK)



Sources: Davidsson, D. (1931:1) pp. 205, 211, Lindahl et al. (1937:2) p. 585, Sammandrag af Bankernas Uppgifter 1874-1900, Schön, L. (1999), Sveriges Riksbank (1931) pp. 18-31, 54-71

The not so surprising result of this exercise in calculating official net foreign assets from the current account is that Sweden had a negative monetary base. This poses an

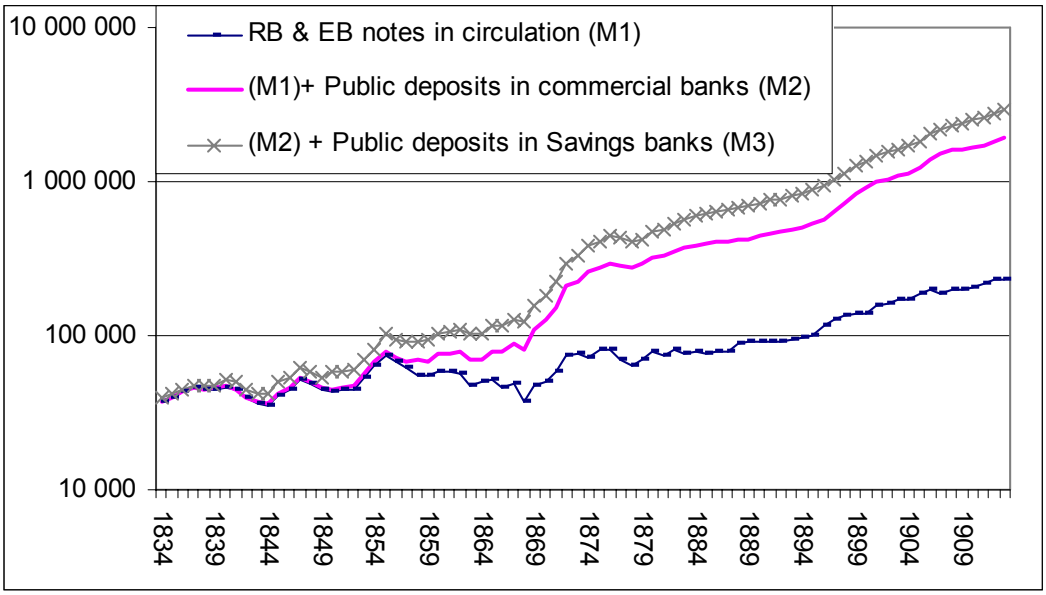
[24] Officer, L.H. (2002) p. 127

intriguing question: If official long term borrowing is not part of the monetary base, how should the capital flows associated with such borrowing be treated? Can the foreign debt position of the National Debt Office be ignored simply because the Office had no responsibility for the specie standard? Clearly, methodological issues arise when defining the monetary situation of a country dependent on international capital and a large part of whose money supply consists of private bank notes. This exercise demonstrates that spatially and chronologically independent monetary concepts can become problematic when they are to be made operational. There will always be some questions as to what items are to be included. Inevitably, these monetary measures will have to be considered on a case by case basis.

The Money Supply

In addition to the so called monetary base, a more appropriate measure of the circulating money supply was the quantity of Riksbank and Enskilda bank notes outstanding, minus the Riksbank notes held as reserves by the Enskilda banks. As a result of the small number banking offices and their limited hours of operation, demand deposits in commercial banks were not readily accessible in nineteenth century Sweden.[25]

Figure 6: The Swedish Money Supply in terms of M1, M2 and M3 in logarithmic form, 1834-1913 (1000's SEK)



Sources: Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, SCB (1960) pp. 99, 102-103, Sveriges Riksbank (1931) pp. 54-71, 172-185

[25] See Ögren, A (2003c)

No matter what the theoretical definition states, there was a clear difference between money circulating as Enskilda bank notes and being held as deposits. Under these circumstances, the above measure of the total stock of notes in circulation is labeled M1. M2 is defined as M1 plus the public's deposits in commercial banks and M3 as M2 plus the public's deposits in savings banks. The considerable business activity of the Swedish savings banks makes M3 a more useful measure than M2.[26] The two periods of substantial commercial bank establishment, the late 1860's and the mid 1890's, both display a marked acceleration in the growth of the two money supply measures, M2 and M3.

The Flexibility of the Riksbank's Reserves and the Practice of Monetary Discipline

Qualitative sources clearly demonstrate that changes in the size of the Riksbank's reserves was the signal that action to preserve convertibility was required. Frequently, the initial reaction of the Board of the Riksbank was to add to those reserves considered as legal backing for the Bank's notes. When the outflow of reserves persisted, however, the Board was forced to decrease its notes in circulation, that is to say, the money supply.[27]

International Capital and the Riksbank's Reserves

Starting in the late 1850's, the National Debt Office imported capital to finance the building of the national railway system. In addition, some of these loans were taken to alleviate distress on the domestic credit market. It has been estimated that by 1910 the average Swede owed more to foreign countries than did the residents of any other country in the world. Sixty years of chronic current account deficits had increased the foreign debt to an amount equal to three quarters of the Country's entire GDP.[28]

As can be seen in Figure 7, changes in the reserves of the Riksbank were small compared to the current account balance. Moreover, the reserves did not consistently

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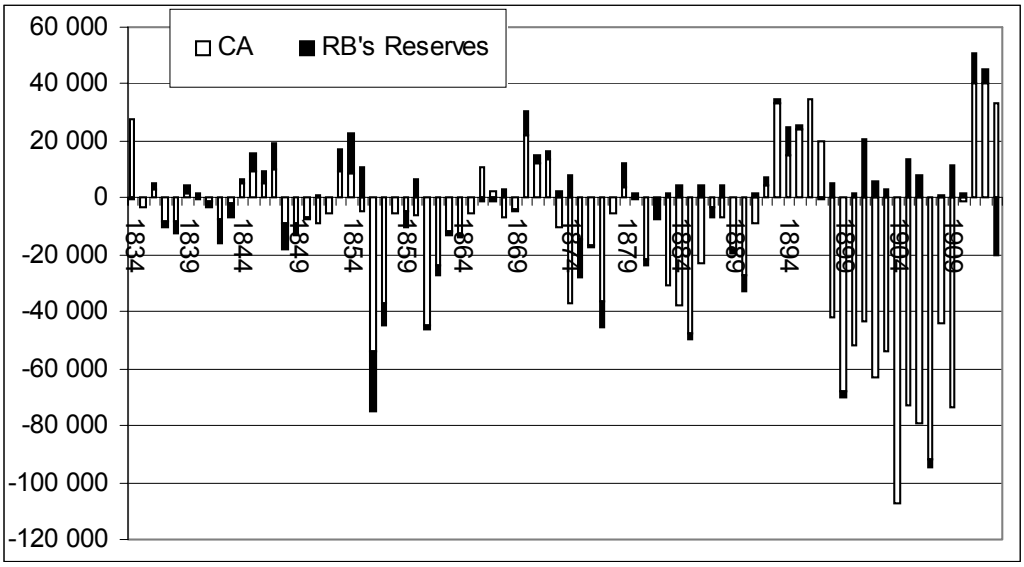
[26] See Lilja, K. (2000), Petersson, T. (2000). The money stock 1871-1971 calculated in the study of Jonung, consisted of the volume of Enskilda and Riksbank notes held by the public plus deposits from the non-banking sector in commercial banks (Jonung, L. (1975) pp. 13, 208-211).

[27] See BaU 1834 – 1900 No 1 (Reports from the Board of the Riksbank to the Parliament), Davidsson, D. (1931:2) pp. 145-146, RbFP 1856 – 1859, 1869 – 1881, RbFSP 1869 – 1881, Ögren, A. (1995) pp. 18, 30, 36. See also Ögren, A. (2003b).

[28] Schön, L. (2000) p. 270. In spite of this, the National Debt Office that very same year launched a large bond loan on the foreign market to ease the constrained situation on the Swedish money market (Schön, L. (2000) p. 262). See also Ögren, A. (2003b).

move in the opposite direction of the current account, illustrating the importance of capital imports. Indeed, to simultaneously sustain imports, maintain the money supply and protect the specie standard would have been impossible without the international capital market.

Figure 7: Annual Current Account and Changes in Riksbank Reserves, 1834 – 1913. 1000's SEK



Sources: Schön, L. (1999), Sveriges Riksbank (1931) pp. 54-71

The Swedish experience was that business fluctuations impacted trade activities. During years of crisis, imports declined more than exports, while during years of rapid economic growth, imports increased more than exports. Between 1834 and 1913, annual changes in imports were more closely correlated with changes in GDP, measured either in current prices or in volume, than were changes in exports.

Figure 8: Correlations Between Annual Changes in Imports and Exports with Annual Changes in GDP , 1834-1913.

	D(EXPORTS)	D(IMPORT)
D(GDPCV)	0.30	0.76
D(GDPVOL)	0.17	0.52

Sources: Krantz, O. (1997) pp. 12-14, 20-22, Lindahl, E. et al. (1937:2) p. 585, Schön, L. (1999)

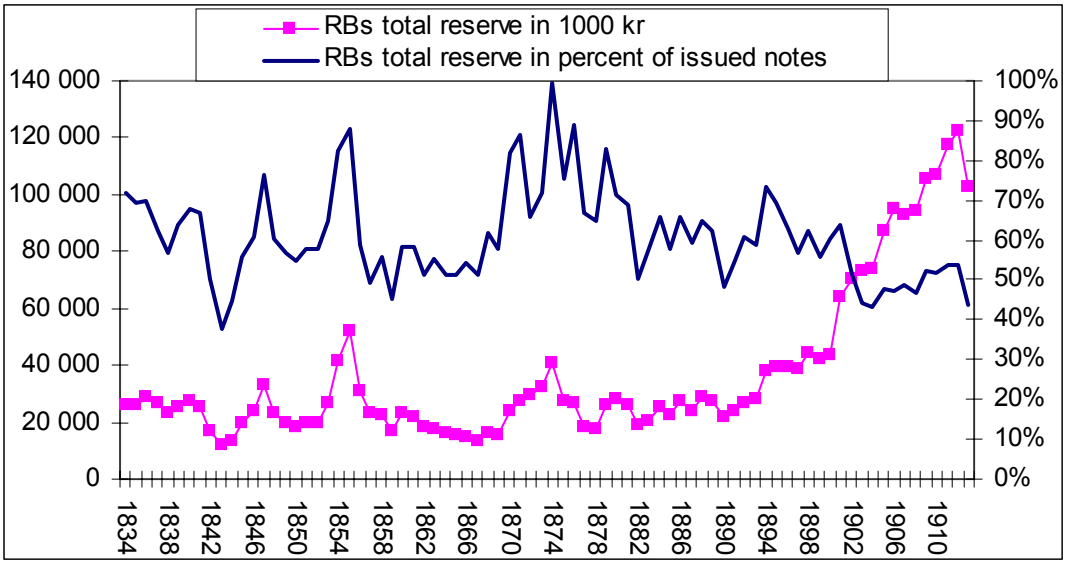
From a pure balance of trade perspective, the recessions were beneficial. At the same time, however, there was a shrinking of the Riksbank's reserves. Throughout the period from 1834 until 1913, the Riksbank's reserves were positively associated with the international business cycle. That is to say, foreign crisis were reflected in Sweden through decreasing reserves. Despite theoretical predictions to the contrary, in an

international exchange rate system based on specie it was possible for reserves in various countries to shrink, or increase, simultaneously.[29]

The Flexibility of Riksbank Reserves

Try as it might, the Riksbank was not able to insulate the Swedish economy from the effects of international capital flows. This became increasingly apparent after foreign borrowing started to rapidly increase beginning during the 1850's. What the Bank could do, however, was to protect the relationship between its note issue and its reserves which served as the basis for international convertibility.

Figure 9: The Reserves of the Riksbank at Current Prices (1000 SEK), and the Percentage Reserve Backing of Its Note Issue, 1834-1913.



Source: Sveriges Riksbank (1931) pp. 54-71

Since the capital imports were long used to finance the import of good and services, the reserves of the Riksbank did not start to grow until the end of the nineteenth century. The reason that a small, capital importing, country such as Sweden could mitigate the effects of the international business cycle can possible be traced to the composition of the Riksbank's reserves. Despite the theoretical mechanisms of the specie system, based as it was on a finite, world wide, stock of high powered money to be used as reserves and a fixed relationship between those reserves and the money supply, the system in

[29] The correlations between monthly changes in percent of the reserves of Bank of England, Banque de France and the German Reichsbank for the period 1880 until 1913 were not negative. A small positive correlation was found between the reserves of the German Recihsbank and the Banque de France (0.190), and a stronger correlation between the German Recihsbank and the Bank of England (0.463), both these

fact had a degree of elasticity. The reserves of the Riksbank deviated from the ”ideal” specie standard model in three regards:

First, during the business cycle the Riksbank could vary its note issue within certain legal parameters. That is, it could utilize its right to issue notes to a different extent during periods when capital was flowing in or out. During most of the period between 1834 and 1913, the Bank allowed the degree of backing for its notes to vary with the size of its reserves.[30]

Second, the Riksbank could alter the composition of its formal reserves and other assets, as well as of its liabilities. Thus the Bank could hold assets that did not qualify as backing for notes but which could be transformed into reserves through sale in the domestic or the international capital market. In 1872, the Riksbank established a fund consisting of assets that did not qualify as reserves but which were to be used to offset, and thus sterilize, outflows of reserves.[31] In addition the bank utilized open market operations to increase the demand for Swedish currency. This was done to preserve the Swedish currency's value and even, to the extent possible, reduce its variability.[32]

Third, starting in 1845, foreign assets, as well as specie, were considered to be part of the Bank's formal reserves. It is possible that the fact that the Riksbank was the central bank of a small peripheral country allowed it make its reserves more elastic than otherwise would have been possible under the specie standard. Credit instruments outside the finite, theoretical, world stock of specie could be used as reserves. The Riksbank's foreign assets that counted were foreign national government bonds, deposits with banks and banking firms and, between 1858 and 1872, foreign bills of exchange.

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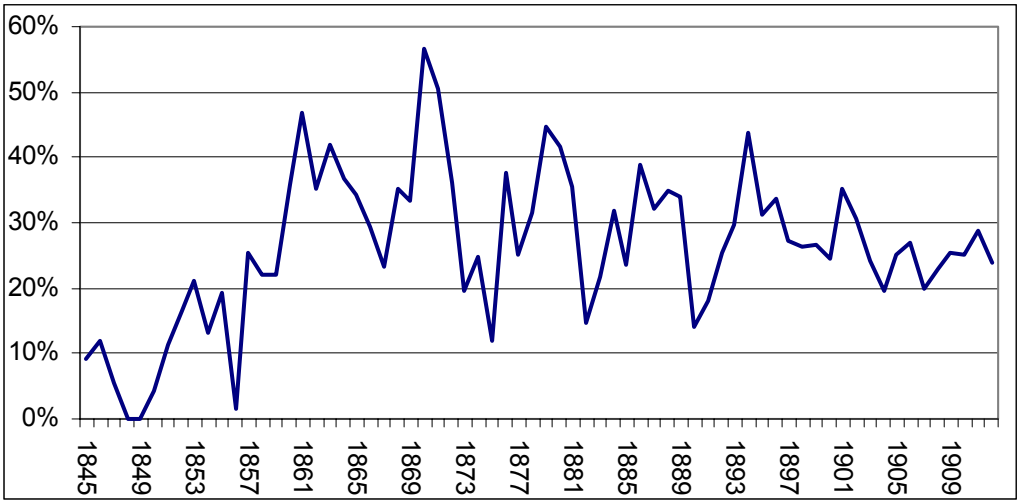
were significant at the 1 % level. No significant correlation was found between the reserves of Bank of England and Banque de France. (Flandreau, M. (2000)).

[30] Correlations between percentile changes in the size of the reserves and the backing of notes were highly positive and significant at the 1 % level for both the silver and the gold standard period.

[31] Brisman, S. (1931) pp. 116-119, 143-145, Ögren, A. (1995) pp. 22-23, 34-40. The Riksbank acted in this manner during the entire period, and it should be noted that besides ensuring convertibility the Riksbank was meant to provide credits in a stable manner. This was of course far from as important as maintaining international convertibility, but it shows that the working of the Riksbank under the classical specie standard did not admit to any 'rules of the game'.

[32] See Lobell, H. (2000)

Figure 10: Foreign Holdings as a Percentage of Total Riksbank Reserves, 1845-1912



Source: Sveriges Riksbank (1931) pp. 54-71

The Swedish experience was that if the Riksbank transferred purchasing power by purchasing the State bonds of one of the core countries of the specie standard, this would not force the Bank to reduce its note issue. It only constituted the exchange of one type of reserve for another. If the central banks of other specie standard countries also held the bonds of other specie standard governments as formal reserves, then such purchases would increase total reserves. In addition, if expectations concerning further growth of these economics was positive, then the value of these items used as reserves would also increase. Furthermore, the holding of reserves in the form of bonds and deposits had the additional advantage that they yielded interest, thus further helping to consolidate the Riksbank's reserve position.

Measuring Monetary Discipline

Assuming that the specie standard worked in accordance with the monetary approach to the balance of payments makes it possible to evaluate the degree of monetary discipline exercised during various periods. The measure of monetary discipline used is the ratio of the monetary base to the stock of specie. The more the monetary base is allowed to expand relative to the stock of specie, the less strict the specie standard.[33] The specie stock used for this purpose is the sum of the specie holdings acceptable for use as reserves by the Riksbank and by the Enskilda banks.

An alternative perspective on monetary discipline results from focusing on the operations of the central bank. It can be argued that specie holdings per see are more a

[33] Officer, L.H. (2002) pp. 136-137

measure of how well the Country followed the rules of the specie standard rather than of how well the fixed exchange rate was protected.[34] It was more efficient for a small Country to maintain reserves in the form of British and German Government bonds. In reality, international transactions were not settled with specie. Thus, holders of Swedish currency where not interested in exchanging it for specie.

Figure 11: The Mean Value of the Ratio of the Monetary Base to the Stock of Specie and to the Reserves of the Riksbank

Mbase/Specie	Mean Value	Period	Mean Value	Period	Mean Value
Silver Std, 1834-1873.	2,51	1834-39	1,67	1870-79	2,32
Gold Std, 1874-1913 S	2,28	1840-49	2,17	1880-89	2,25
Gold Std US., 1879-1913	2,17	1850-59	2,37	1890-99	1,99
		1860-69	3,38	1900-13	2,63
Mbase/Rbreserves	**Mean Value**	**Period**	**Mean Value**	**Period**	**Mean Value**
Silver Std, 1834-1873	2,26	1834-39	1,67	1870-79	1,93
Gold Std, 1874-1913	1,80	1840-49	2,12	1880-89	2,29
		1850-59	1,98	1890-99	1,93
		1860-69	2,42	1900-13	2,00

Sources: Davidsson, D. (1931:1) pp. 205, 211, Officer, L.H. (2002) p. 137, Sammandrag af Bankernas Uppgifter 1874-1900, Sveriges Riksbank (1931) pp. 18-31, 54-71

Discipline was somewhat less strict under the silver than under the gold standard. Judging the entire period, discipline was strictest in connection with the readoption of the silver standard in 1834 and the most lax during the economically gloomy 1860's. During that decade, reserves flowed out during the Danish-Prussian War of 1864, as the result of international crises and to pay for the food imports required to mitigate the famine caused by the crop failures between 1866 and 1869.[35] The relatively low discipline observed during the early years of the twentieth century can only partly be blamed on the replacement of Enskilda bank notes since the total supply of notes in circulation increased.[36]

[34] The fact that the Riksbank held sufficient British, and German, Govenrmental bonds in the reserves was probably more important for adhering to the silver and gold standards, than was the fact that the Enskilda banks held specie in their reserves. But the measure of monetary discipline by holding specie will conclude otherwise.

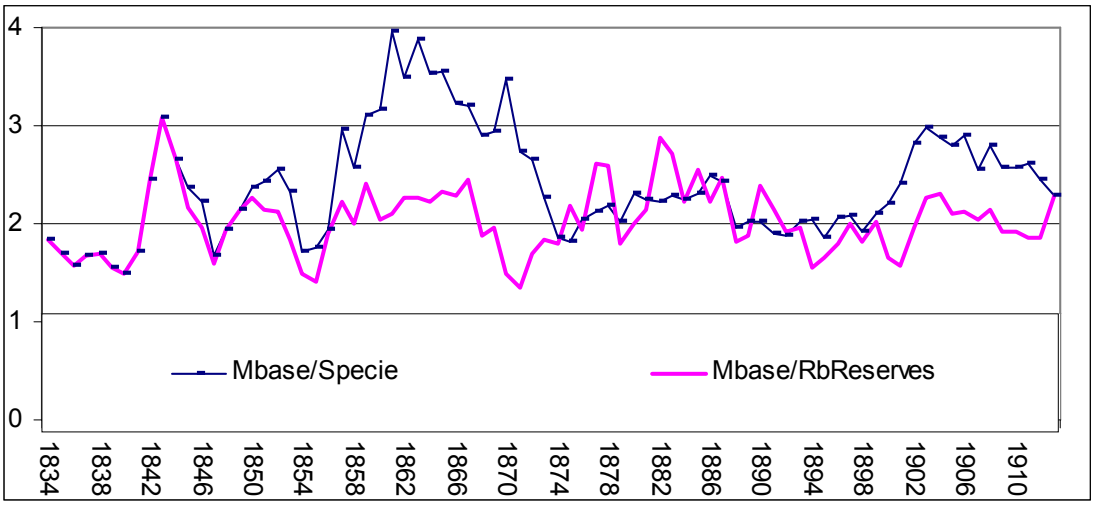
[35] Under the flag of Scandinavianism, Sweden had promised to support Denmark in case of war. As this war became a reality 1864, Swedish reserves rapidly decreased until Sweden withdrew this "promise". The great famine 1866 until 1868 was a supply crisis, reserves were deployed to import food, but prices remained high and transactions low. Besides the lack of food to trade there was no capacity to transport food to the areas most in need. See Davidsson, D. (1931:2) and Ögren, A. (2000) p. 95 note 43.

[36] See Ögren, A. (2003c).

Starting in the 1850's, the measures of monetary discipline changed significantly. Overall, the gold standard was a less ”pure” specie standard than was the silver standard. Interestingly enough, the National Debt Office began to borrow on international markets at about the same time that it became possible to substitute foreign assets for specie reserves.

Despite the crisis of 1857/58, and the measures the Riksbank took to deal with it, the 1850's do not seem to have been characterized by a specific lack of monetary discipline. Figure 12 below shows the monetary pyramid ratio for each year during the entire period.

Figure 12: Monetary Pyramid Ratios, 1834 – 1913



Sources: Davidsson, D. (1931) pp. 205, 211, Sammandrag af Bankernas Uppgifter 1874-1900, Sveriges Riksbank (1931) pp. 18-31, 54-71

A review of the annual monetary pyramid ratio of the monetary base to the stock of specie yields several interesting observations concerning the measurement of monetary discipline. First, the peak indicating lax monetary discipline in the early 1840's can be credited to the redemption with specie of the Riksbank notes circulating in Finland. This episode of reduced monetary discipline also coincided with the practical abandonment of the fixed exchange rate. Here the pyramid ratio indicates decreased monetary discipline by the central bank.

Second, the sharp rise, once again indicating reduced monetary discipline, starting with the crisis of 1857 coincides well with the actions of the Riksbank during the crisis itself.[37] The short term loan taken in Hamburg in January 1858 to sustain the domestic

[37] See Ögren, A. (2003b).

credit market, however, indicates a higher degree of monetary discipline than during the following years. Given the definition of the monetary base, raising foreign capital, thus decreasing the net foreign assets of the Riksbank, decreases the ratio of the monetary base to the stock of specie. This, in turn, indicates a higher degree of monetary discipline. When the loan is repaid, the opposite happens. This effect is doubled if the foreign loan is used to import specie. In that case, not only does the monetary base decrease, but the holdings of specie increase. Thus, when the international capital market is utilized to maintain domestic liquidity, while still preserving the fixed exchange rate, the measure of monetary discipline is distorted, or at least the effect is lagged. That is why monetary discipline appears to be at its weakest during the 1860's when the crisis loan was being repaid.[38]

Third, with the private banks scheduled to begin holding specie in 1874, the ratio decreased rapidly from 3.5 in 1870 to less than 2.3 in 1873, possibly as a consequence of the conversion to the gold standard in 1873. The ratio then remained reasonable stable until the turn of the twentieth century when the Riksbank greatly expanded its note issue.

Differences in the results of the two measures of monetary discipline was most significant from the mid 1850's to the mid 1870's. Measuring monetary discipline solely by specie holdings creates problems when other assets also are important. Nevertheless, as the experience of the crisis of the late 1850's demonstrates, measuring discipline by including the formal reserves allows the authorities to tamper with the size of the reserves.

Monetary discipline was imposed by foreign lenders, it did not follow automatically from adopting the gold standard. Instead, the decision to adopt the gold standard was taken in order to remain in harmony with the most important lenders.

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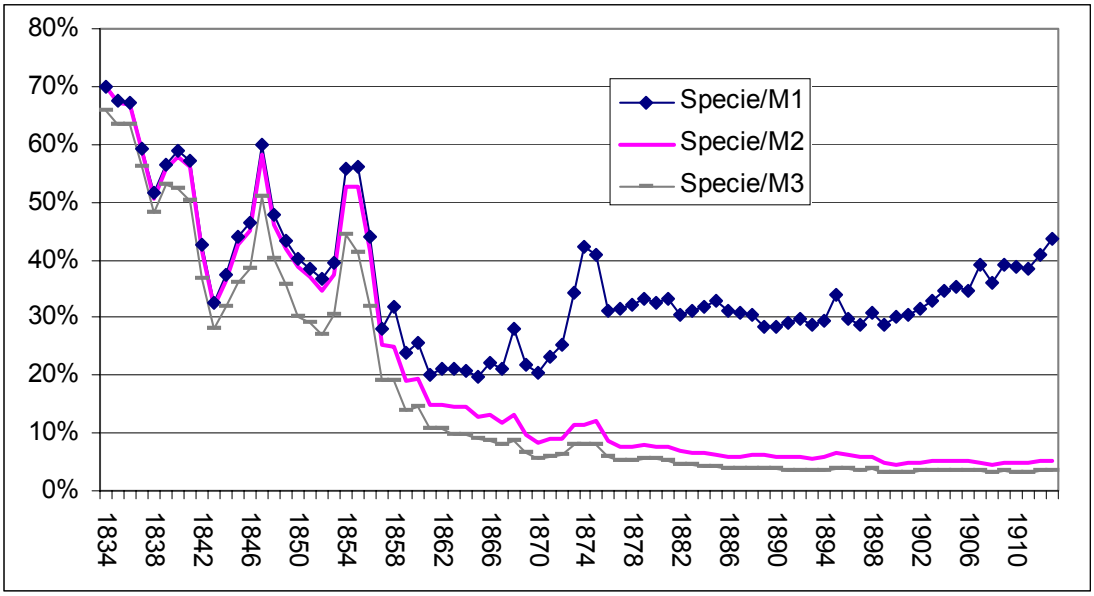
[38] The choice of how to fund increases in the monetary base affected the measure of monetary discipline. This stresses the difficulty of definitions, and their impact on results, even more. Consider the two likely scenarios: 1) the central bank selling off domestic treasury bonds abroad, then using the funds to purchase specie. This will increase monetary discipline. As specie is part of the monetary base, the monetary base as well as the central banks holdings of specie will nominally increase equally in size. But, since specie is a smaller portion than the monetary base, the relative increase in specie holding increases more then the relative increase in the monetary base increasing monetary discipline. 2) The central bank borrowing money from abroad to purchase specie. As in the former example this will increase both specie holdings and the monetary base. However, since net foreign assets of the central bank is included in the monetary base, the decrease in net foreign assets will cancel out the import of specie, that is the increase in the monetary base. Thus, in the latter example the disciplinary effect of the central bank action will be higher than in the former since the amount of specie increases but not the total amount of the monetary base.

The Growth of the Money Supply

The question is, how was the growth in the issue of Riksbank notes and the money supply related to specie holdings, to the Riksbank's reserves and to the monetary base? In theory, the specie standard emphasizes specie holdings as the basis for expansion of the money supply. Even under the gold and silver standards, however, specie became a less and less important part of the money supply as the banking system expanded and other items increasingly served as reserves.

Figure 13: Ratios of the Stock of Specie to the Money Supply (M1), (M2), and (M3), 1834-1913



Sources: Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, SCB (1960) pp. 99, 102-103, Sveriges Riksbank (1931) pp. 54-71, 172-185

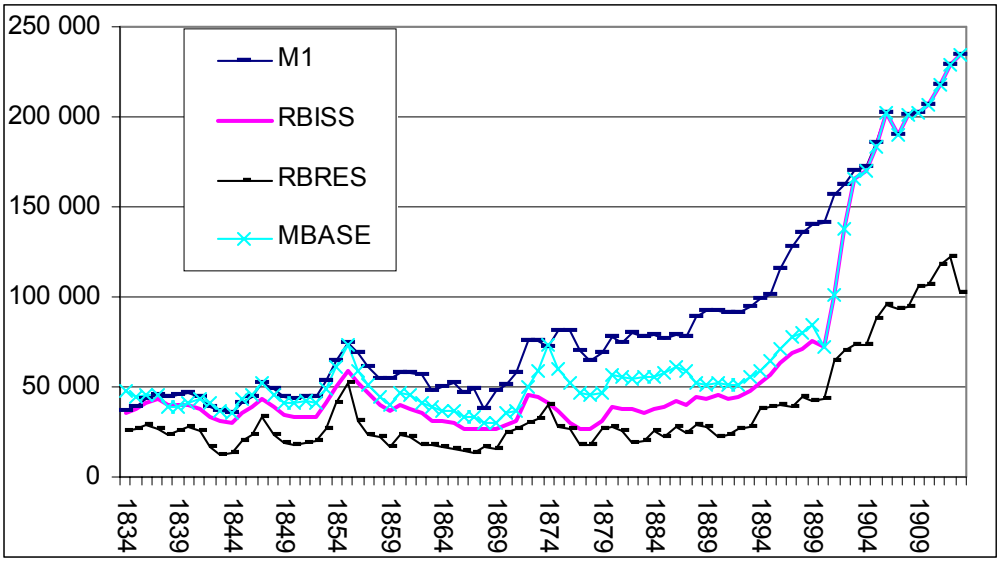
The money supply measure used by Jonung in his study is what is here labeled M2, that is the public's holdings of Riksbank and Enskilda bank notes plus its deposits in commercial banks. Based on five year averages, Jonung determined that under the gold standard there was stable parallel growth in the gold reserve and the money supply. He offered this result as evidence supporting Cassel's theories of price level movements.[39]

Figure 13, however, raises doubts about such a relationship since prices did not move in the same direction as the ratios pictured. The figure also puts into question the importance of focusing on the specie part of the money supply in explaining the workings of the adjustment mechanism.

[39] Jonung, L. (1975) pp. 139-142, 144-147, 153

According to the monetary approach to the balance of payments, a relationship exists between the monetary base and the various measures of the money supply, including the public's bank deposits. Jonung also noted a pattern indicating that the growth of the money supply was largely dependent of the growth of the monetary base.[40] In fact, however, the Swedish money supply in terms of M1, M2 or M3 did not grow in accord with the expansion of Riksbank reserves, Riksbank notes issued or the monetary base.[41]

Figure 14: Money Supply (M1), Issued Riksbank Notes (RBISS), Formal Reserves of the Riksbank (RBRES) and the Monetary Base (MBASE), 1834-1913 (1000's SEK).



Sources: Davidsson, D. (1931:1) pp. 205, 211, Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, Sveriges Riksbank (1931) pp. 18-31, 54-71

While the Riksbank's note issue increased at the same rate as its reserves under the silver standard, this was not the case under the gold standard. Instead the issuance of notes greatly exceeded the increase in the Bank's reserves. This new development can be credited largely to the issuance of Riksbank notes, not accompanied by any increase in reserves, intended to replace the Enskilda bank notes that were being withdrawn from circulation at the turn of the twentieth century. Clearly these Enskilda bank notes earlier

[40] Jonung, L. (1975) pp. 37, 48-50, 63

[41] For the entire period 1834 until 1913, all the series on money supply, issued Riksbank notes, the monetary base and Riksbank reserves were non-stationary. Even though all series are non-stationary over the entire period 1834-1913, a cointegration analysis might be misleading, as the non-stationarity seemed to be the result of a structural break late in the period. Still, an attempt to conduct a Johansen's test for cointegration over the entire period 1834 until 1913 does not indicate any long term relation with M1, M2 or M3 for any of the variables of RBISS, RBRES or MBASE. In lack of a better method, cointegration tests started with a large number of lags that was decreased (see Maddala, G.S. & Kim, I-M. (1998) p. 191)

had played a major role in providing the money that the convertibility requirements had prevented the Riksbank from supplying.[42]

Figure 15: Growth in Percentage of the Money Supply (M1), (M2), (M3) Issued Riksbank Notes (RBISS), Formal Reserves of the Riksbank (RBRES) and the Monetary Base (MBASE)

Growth under Period	M1	M2	M3	RBISS	RBRES	MBASE
1834-1913	633%	5184%	7345%	650%	395%	493%
1834-1900	380%	2456%	3453%	199%	167%	151%
1834-1873 (Silver Std.)	204%	610%	841%	124%	124%	124%
1874-1913 (Gold Std.)	325%	731%	749%	578%	253%	322%
1901-1913	150%	194%	197%	232%	159%	232%

Sources: Davidsson, D. (1931:1) pp. 205, 211, Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, SCB (1960) pp. 99, 102-103, Sveriges Riksbank (1931) pp. 18-31, 54-71, 172-185

Since virtually no Enskilda bank notes were in circulation at the beginning of the period, and none at all after 1906, for the entire period there is a virtual identity between the increase in M1 and the issue of Riksbank notes. Looking at sub periods, however, makes it clear that M1 grew more or less independently of the other variables in Figure 15.

If the money supply grew independently of the level of reserves, how was the specie standard maintained? Triffin has argued that the gold standard era was more a period of credit money than of gold. Thus, the focus on the international adjustment mechanism overshadowed the forces that controlled the overall rate of monetary expansion, a rate which all the individual countries had to accept. When the credit economy was growing, all countries with stable exchange rates were bound to experience approximately the same pace of money supply growth. If that had not been case, it would have been impossible to maintain stability in international exchange rates. According to the monetary approach to the balance of payments, inflationary pressure would have led to a balance of payments deficit which, in turn, would have weakened the reserve position of the domestic economy.[43]

This argument made by Triffin also validates the importance of the composition of central bank reserves. In particular, the use of foreign financial assets as part of formal reserves, and thus as backing for note issuance, partly could explain the overall monetary expansion under the gold standard.

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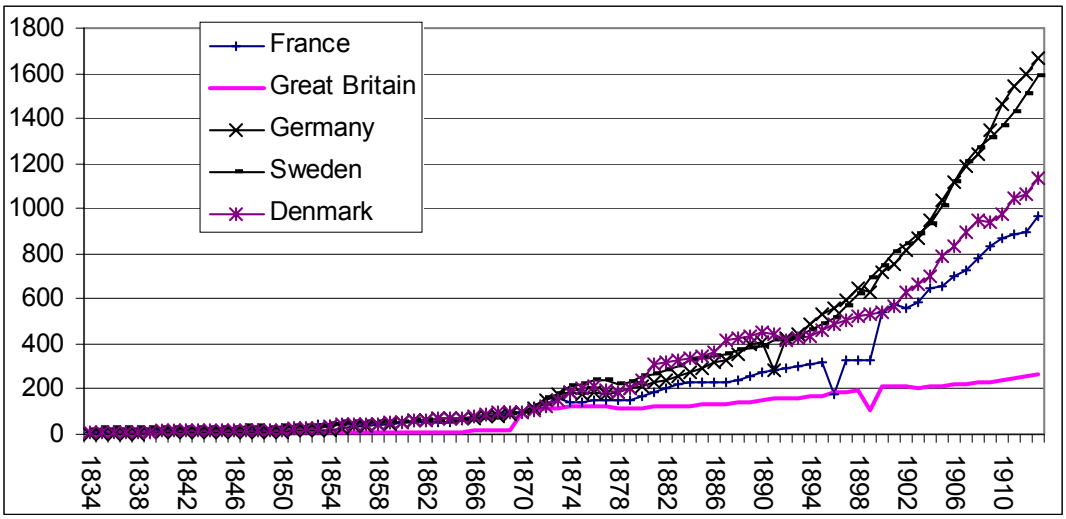
[42] See Ögren, A. (2003c).

[43] Kenwood, A.G. & Lougheed, A.L. (1999) p.118, Triffin, R. (1985) pp.121, 128-129, 133

Figure 16: Circulating Notes plus the Public's Deposits in Commercial and Savings Banks (M3) in Sweden and Some of Its Principal Trading Partners, 1834 – 1913. Current Value Indexes, 1870=100.



Sources: Mitchell, B.R. (1998) pp.784-789, 793-195, 800-803, Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, SCB (1960) pp. 99, 102-103, Sveriges Riksbank (1931) pp. 54-71, 172-185

The indexes of the money supply in various countries over the period 1834 to 1913 clearly display an upward trend. Among the countries in Figure 16, this is particularly striking for Sweden and Germany. Since Germany was the foreign economy with the greatest impact on Sweden, this similarity might indicate a long run relationship in the growth of the money supply.[44]

This argument might explain why the growth of the money supply in the various countries on the classical specie standard was so similar. Nonetheless, maintaining convertibility in the long run probably would not have been possible had the growing money supply not been related to economic growth. The results of Johansen's test indicates that GDP at constant prices (GDPVOL) and the measure of the money supply consisting of circulating Riksbank and Enskilda bank notes were cointegrated. Economic growth, as measured by GDPVOL, however, was not cointegrated with any other measure of the money supply.[45] In addition, neither of the various measures of the money supply were cointegrated with growth in the commercial banking sector, measured as commercial bank assets and commercial bank credit.

[44] Johansen's test indicates that cointegration, a long run relationship, existed between the Swedish money supply and that of Denmark, France, Germany and Great Britain in nominal values. But the likely problems of what these figures actually contain makes it risky to draw any conclusions based on this test.

[45] I thank Camilla Josephsson for performing this cointegration test for me.

Figure 17: Johansen's test on Cointegration between Real Output (GDPVOL) and the Money Supply in terms of Circulating Notes in stable prices (MIDEF), 1834-1913.

Sample(adjusted): 1837 1913				
Series: GDPVOL M1DEF				
Lags interval (in first differences): 1 to 2				
Unrestricted Cointegration Rank Test				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.296869	30.57333	15.41	20.04
At most 1	0.043854	3.453022	3.76	6.65
*(**) denotes rejection of the hypothesis at the 5%(1%) level				
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				

Sources: Krantz, O. (1997) pp. 20-22, Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, SCB (1960) pp. 99, 102-103, Sveriges Riksbank (1931) pp. 172-185

The existence of a cointegration vector implies that there was a stable, stationary, relationship in the residual between economic growth and the money supply. Thus, in the long run, economic growth and the growth of the money supply in terms of circulating Riksbank and Enskilda bank notes were related.[46] The lack of a measurable relationship between growth in the money supply and in the reserves, or the monetary base, does not mean that no relationship existed. The question raised by existing theory is what was the relationship among changes in reserves, changes in the money supply and changes in prices.

What Caused Changes in the Money Supply?

Theoretically, both the monetary approach to the balance of payments and the price specie flow mechanism, focuses on an internal relationship between changes in reserves (the monetary base) and changes in the money supply. The difference between the two lies in the causality. While the price specie flow model in conjunction with the quantity theory of money leads to the result that changes in reserves due to international capital flows induces changes in the money supply, the monetary approach to the balance of payments concludes that changes in the money supply results in changes in reserves. A study comparing the gold standard with other international monetary arrangements by Bayoumi and Eichengreen supports the latter view. That is, under the gold standard the

[46] The Vector Error Correction on these variables actually suggests that the output (GDP) was dependent, or at least preceded, by the money supply (see Appendix Figure 3 in Appendix A).

money supply adjusts through the balance of payments, thereby restoring equilibrium in asset and commodity markets.[47]

Furthermore, as noted above, the minutes of the Riksbank Board, as well as the Board's reports to Parliament, support the validity of the monetary approach to the balance of payments. Sufficient notes were supplied and, initially, reserves were increased as needed. Only when convertibility was threatened would the note issue be constrained.

A question is whether the money supply caused price to move or vice versa? One tendency supporting the monetary approach to the balance of payments is the existence of the positive interlinking of price movements among countries predicted by the purchasing power parity hypothesis.[48] Swedish wholesale prices and, to a slightly lesser degree, consumer prices were indeed correlated with those of the Country's trading partners.

Figure 18: Correlations Between Annual Percentage Changes in Swedish Wholesale and Consumer Prices with Those of her Principal Trading Partners, 1834-1913

Wholesale Price indices	**France**	**Great Britain**	**Germany**	
Sweden, 1861-1913	0.731*	0.780*	0.753*	
Consumer Price indices	**France**	**GB (England)**	**Germany**	**Denmark**
Sweden, 1834-1913	0.373*	0.360*	0.515*	0.601*
Sweden, 1834-1873 Silver std	0.458*	Not significant	0.541*	0.532*
Sweden, 1874-1913 Gold std	Not significant	0.549*	0.544*	0.739*

* Significant at least at 5 %

Sources: Mitchell, B.R. (1998) pp. 856-859, 863-865, Myrdal, G. & Bouvin, S. (1933) pp. 196-199

For the entire period 1834-1913, Swedish consumer prices closely tracked those in Germany and Denmark well. During the gold standard period, the correlation with British prices increased while that of French prices became statistically insignificant. During the entire period, Sweden's place in the "German economic bloc" was of considerable significance. Starting with the adoption of the gold standard, Swedish consumer prices were remarkably closely synchronized with those in Denmark.[49]

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[47] Bayoumi, T. & Eichengreen, B. (1995) pp. 7-11, 20-21. This study included seven countries, among them Sweden

[48] Gomes, L. (1993) pp.166-167, McCloskey, D.N & Zecher, J.R. (1985) pp. 69-71. Here it would also be expected that wholesale prices were more prone to internationally move together than consumer prices, since the latter holds a larger amount of internationally less tradable goods than the former (for instance housing).

[49] This might be explained with the fact of Denmark and Sweden being neighboring countries, but perhaps more significant was the Danish and Swedish establishment of the Scandinavian Currency Union (*Skandinaviska Myntunionen)* in connection with the switch from the silver to the gold standard in 1873,

These correlations definitely support the existence of international integration. They are insufficient, however, to prove that the monetary approach to the balance of payments was valid in all respects. In order to sort this problem out, the question has been subjected to a VAR-model causality test.

The measure of the monetary base utilized is that excluding the net foreign assets of the National Debt Office. The test applied to the relationship between the monetary base and the money supplied revealed no significant causality whatever. The balance of payments series in stable prices, however, had a positive effect on changes in the money supply (M1) measured at stable prices. This result was not statistically significant when the gold standard period was treated separately.[50]

There are significant results of the test of the casual link between Riksbank reserves, the money supply and prices. The somewhat puzzling outcome of this VAR causality test is that while the money supply increased in response to increased reserves during the previous year, it also increased if the money supply in terms of circulating notes (M1) had decreased. Changes in the money supply in terms of notes in circulation plus the public's deposits in commercial banks (M2) had a positive effect on reserves two years later. But, changes in circulating Riksbank and Enskilda bank notes (M1) after two years negatively affected reserves.[51]

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where also Norway joined in 1875. The union made coins convertible at par, but did not include notes. In 1894 notes became convertible at par between Sweden and Norway, and in 1901 with Denmark. See Henriksen, I & Kærgård, N. (1995) and Talia, K. (2001).

[50] See Appendix Figures 9, 10, 11, and 12 in Appendix B. This result stresses the difficulty of estimating the monetary base in accordance with a static set of rules and still making it a significant measure for different types of economies.

[51] See Appendix B for tests and a complete read out of the model. VAR models with five lags have been tested. The 2-lag model was selected due to its relatively high adjusted R2 value and relatively low Akaike and Schwartz values.

Figure 19: Vector Auto Regression on the Consumer Price Index (CPI), Money Supply (M1DEF), (M2DEF), (M3DEF), and Riksbank Reserves (RBRESDEF), 1834-1913. 2 lags, variables deflated by the consumer price index and in logarithmic form.

Sample(adjusted): 1837 1913					
Included observations: 77 after adjusting endpoints					
t-statistics in [ ]					
	DLOG (CPI)	DLOG (M1DEF)	DLOG (M2DEF)	DLOG (M3DEF)	DLOG (RBRESDEF)
DLOGCPI(-1)	0.505055	-0.675919	-0.187056	-0.197512	0.013963
	[4.02344]*	[-2.07237]*	[-0.60316]	[-0.72937]	[0.01853]
DLOGCPI(-2)	-0.179828	-0.033946	-0.071144	-0.075151	-1.353373
	[-1.52134]	[-0.11053]	[-0.24362]	[-0.29471]	[-1.90702]
DLOGM1DEF(-1)	0.242374	-0.424197	-0.393267	-0.331455	0.378014
	[2.99483]*	[-2.01728]*	[-1.96687]	[-1.89847]	[0.77797]
DLOGM1DEF(-2)	0.092010	-0.404555	-0.476446	-0.436789	-1.616502
	[1.11138]	[-1.88070]	[-2.32941]*	[-2.44565]*	[-3.25219]*
DLOGM2DEF(-1)	-0.235246	0.508077	0.684517	0.714533	1.624533
	[-1.34616]	[1.11896]	[1.58548]	[1.89535]	[1.54836]
DLOGM2DEF(-2)	-0.010351	0.502378	0.753044	0.716169	2.916830
	[-0.05813]	[1.08574]	[1.71161]	[1.86419]	[2.72812]*
DLOGM3DEF(-1)	0.236773	-0.613903	-0.545323	-0.586789	-2.123717
	[1.25482]	[-1.25217]	[-1.16979]	[-1.44154]	[-1.87463]
DLOGM3DEF(-2)	0.000233	-0.262593	-0.285237	-0.280705	-1.718486
	[0.00123]	[-0.53380]	[-0.60981]	[-0.68727]	[-1.51181]
DLOGRBRESDEF(-1)	0.005985	0.221332	0.121543	0.104796	0.058659
	[0.26055]	[3.70838]*	[2.14172]*	[2.11478]*	[0.42534]
DLOGRBRESDEF(-2)	-0.006199	0.118159	0.010979	-0.008273	-0.139690
	[-0.25846]	[1.89599]	[0.18529]	[-0.15988]	[-0.97004]
R-squared	0.489402	0.291574	0.223869	0.251119	0.282417
Adj. R-squared	0.412038	0.184237	0.106273	0.137652	0.173693

* Denotes significant values at least at 5%

Sources: Myrdal, G. & Bouvin, S. (1933) pp. 196-199, Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, SCB (1960) pp. 99, 102-103, Sveriges Riksbank (1931) pp. 54-71, 172-185

There were also significant results concerning prices. Changes in the money supply in terms of circulating Riksbank and Enskilda bank notes (M1) resulted in a change in consumer prices with a one year lag. The rate of change of prices was also affected by previous prices changes, but these did not have a significant effect on the money supply. Even though the tendency was the same throughout the eighty year period, it was stronger under the gold than under the silver standard.[52]

[52] See Appendix B, Appendix Figures 7 and 8. Although not significant at the 5% level, changes in consumer prices seemed to have a negative impact on the Riksbank's reserves. If so, this supports the idea

The results of the VAR test of causality can be summarized in a model designed to explain changes in domestic prices as depending on changes in domestic monetary variables. The neo classical quantity theory predicts that price effects due to growth in the money supply may be off set by growth in real income. The growth of real output was related to the growth of the money supply measured in terms of circulating notes (M1). Therefore, changes in real GDP is also included in the model determining price movements. Moreover, changes in consumer prices in Germany (GERCPI) is incorporated as a proxy for international price movements.

Figure 20: OLS-regression determining changes in domestic prices (CPI), as dependent on current and prior changes in the variables the German Consumer Prices (GERCPI), the Money Supply (M1DEF), and GDP (GDPVOL), 1834-1913

Dependent Variable: DLOG(CPI)				
Method: Least Squares				
Sample(adjusted): 1836 1913				
Included observations: 78 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000148	0.004142	0.035695	0.9716
DLOG(M1DEF(-1))	0.208837	0.038308	5.451567	0.0000*
DLOG(CPI(-1))	0.431343	0.082337	5.238730	0.0000*
DLOG(GDPVOL)	-0.136901	0.103992	-1.316460	0.1921
DLOG(GERCPI)	0.176576	0.038591	4.575629	0.0000*
R-squared	0.545961	Mean dependent var		0.005182
Adjusted R-squared	0.521083	S.D. dependent var		0.040856
Durbin-Watson stat	2.148764	Prob(F-statistic)		0.000000

* Denotes significant values at least at 5%

Sources: Krantz, O. (1997) pp. 20-22, Mitchell, B.R. (1998) pp. 863-865, Myrdal, G. & Bouvin, S. (1933) pp. 196-199, Post & Inrikes Tidning 1835-1871, Sammandrag af Bankernas Uppgifter 1874-1900, Sveriges Riksbank (1931) pp. 172-185

As predicted by the theory, changes in prices were related to concurrent changes in GDP (by volume). If significant, growth in the GDP acted to cushion the effect of a growing money supply on prices.[53] Prices were positively affected by the money supply in terms of circulating notes (M1) lagged one year. International price movements also clearly affected domestic prices. The largest impact came from domestic price changes lagged one period.

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that the balance of payments was used to restore equilibrium on the money market. The R2 value, the explanatory power (or the goodness of fit value), suggests changes in CPI as being dependent upon changes in the money supply. For tests of the model see Appendix B.

[53] GDPVOL does not appear to be significant and this is not due to problems with multicolinearity (see Appendix C).

This result is consistent with both the quantity theory, and thus with the price specie flow mechanism, and the monetary approach to the balance of payments. It concludes that prices are set in international markets. At same time, however, it was also the case that domestic price changes were connected to domestic changes in the money supply. This was a result of the simultaneous money supply growth experienced by the countries operating under the specie standard. This money supply expansion, however, was not associated with any growth in specie holdings in these countries.

It was argued above that the use of foreign financial liabilities issued in specie standard countries as formal reserves allowed the total supply of reserves to increase, subject only to the existence, as indeed was the case, of a liquid secondary market for these assets. Expectations also affected the value of the reserves. Gold standard economies experienced a simultaneous growth in their money supply. At least in the Swedish case, and in the short run, changes in the money supply preceded changes in consumer prices. That, however, is still consistent with a large share of these consumer prices being determined in international markets.

Conclusions

At the outset of this paper, the causal relationships among the parameters associated with fixed exchange rates were discussed. This discussion was predicated on the observation that the Swedish experience under the gold standard has been presented both within the confines of the price specie flow mechanism and its more recent variant, the monetary approach to the balance of payments. Since the causality inherent in these two theories is mutually incompatible, questions arose concerning how the money supply reacted to changes in international relations as reflected in changes in central bank reserves or the more inclusive balance of payments series.

Following the lead of Jonung and Officer, series of the monetary base and the balance of payments were constructed for the period 1834 - 1913. This section includes a methodological discussion of how best to treat the foreign debts of the authorities as well as the substantial volume of notes issued by private Swedish banks. This discussion underscored the difficulties encountered when applying a static definition of economic concepts to the reality of various types of economies and especially to transitional economies. Indeed, a detailed knowledge of the monetary arrangement of the particular time and place is essential.

The following section dealt with the nature of the international capital transactions that affected the Swedish economy and its level of monetary reserves. Since Sweden was dependent on international capital for imports, economic crises were actually beneficial for her trade balance. The capital flows related to trade in goods and services, however, were small compared to those connected to international borrowing, at least starting in the late 1850's. It was also noted that a common specie standard did not prevent the central bank reserves of these countries from all increasing simultaneously. This was partly due to the elasticity inherent in the system, which left the central bank with some ability to fudge the rules of the game. Of importance for the overall growth of central bank reserves was the inclusion of financial assets held in other specie standard countries.

Foreign assets were a major component of the Riksbank's reserves. This reality has affected the measurement of monetary discipline. Considering only actual holdings of specie results in discipline appearing remarkably lax during the 1860's. If instead discipline is measured in terms of the monetary base to Riksbank reserves ratio, things look somewhat better. Nonetheless, monetary discipline seems to have become more stringent after the international debt became significant starting the late 1860' and early 1870's. Apparently, it was the foreign debt situation, rather than the adoption of the gold standard, that influenced behavior in this regard. What was important was not the switch from silver to gold but the increasing dependence on the international capital market.

The growth of the money supply did not depend on specie holdings, Riksbank reserves or even the monetary base. The only cointegration result that could be identified was between the circulation of bank notes (M1) and real GDP. It does seem as if other monetary aggregates grew simultaneously with the money supply in other countries operating under the specie standard and of major importance to the Swedish economy.

The causality inherent in the system was then tested. Did changes in certain variables effect the money supply or did the opposite relationship hold? Changes in the monetary base or in specie holdings were unrelated to changes in any of the monetary aggregates. Contrary to the qualitative evidence, the statistical tests tended to support the specie flow hypothesis. Changes in central bank reserves, as well as in the balance of payments, positively affected the money supply. Changes in the money supply, in turn, were positively related to the level of consumer prices. At the same time, however,

domestic prices were changing in line with international prices, thus tending to support the monetary approach to the balance of payments hypothesis.

The result was summarized in an OLS-regression model in which current changes in domestic prices were dependent on current changes in international prices. Changes in the money supply in terms of circulating notes (M1) lagged one period and, most importantly, price changes lagged one period also affected price changes positively.

The Swedish money supply grew in line with that of other countries operating under the specie standard. This growth in the money supply, in turn, resulted in increasing international prices during periods of credit expansion that were not also characterized by rapid economic growth. Thus, prices, in addition to being connected to international markets, responded to prior increases in the money supply. This growth in the money supply, however, may only have been tolerated because of the similar monetary growth experienced in other specie standard countries.

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Appendix – Testing the Models

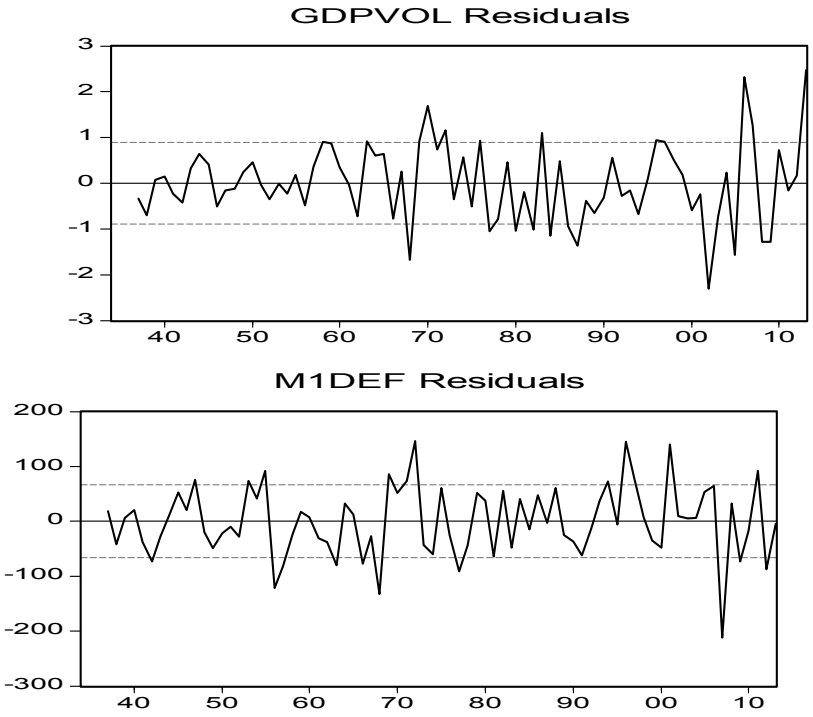
Appendix A – Johansen's test for Cointegration

Appendix Figure 1: Complete readout from Johansen's test on Cointegration.

Sample(adjusted): 1837 1913				
Included observations: 77 after adjusting endpoints				
Trend assumption: Linear deterministic trend				
Series: GDPVOL M1DEF				
Lags interval (in first differences): 1 to 2				
Unrestricted Cointegration Rank Test				
Hypothesized		Trace	5 Percent	1 Percent
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Critical Value
None **	0.296869	30.57333	15.41	20.04
At most 1	0.043854	3.453022	3.76	6.65
*(**) denotes rejection of the hypothesis at the 5%(1%) level				
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				
Hypothesized		Max-Eigen	5 Percent	1 Percent
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Critical Value
None **	0.296869	27.12031	14.07	18.63
At most 1	0.043854	3.453022	3.76	6.65
*(**) denotes rejection of the hypothesis at the 5%(1%) level				
Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels				
Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):				
GDPVOL	M1DEF			
0.059857	0.001305			
-0.254602	0.008094			
Unrestricted Adjustment Coefficients (alpha):				
D(GDPVOL)	0.534560	0.047250		
D(M1DEF)	15.33175	-12.37360		
1 Cointegrating Equation(s):		Log likelihood	-525.5739	
Normalized cointegrating coefficients (std.err. in parentheses)				
GDPVOL	M1DEF			
1.000000	0.021794			
	(0.00953)			
Adjustment coefficients (std.err. in parentheses)				

D(GDPVOL)	0.031997			
	(0.00606)			
D(M1DEF)	0.917712			
	(0.45197)			

Appendix Figure 2: Cointegration Residuals



Appendix Figure 3: Vector Error Correction Model with the Variables GDP in Volumes and money supply in stable prices (M1DEF).

Vector Error Correction Estimates		
Sample(adjusted): 1837 1913		
Included observations: 77 after adjusting endpoints		
Standard errors in ( ) & t-statistics in [ ]		
Cointegrating Eq:	CointEq1	
GDPVOL(-1)	1.000000	
M1DEF(-1)	0.021794	
	(0.00953)	
	[2.28762]	
C	-44.92972	
Error Correction:	D(GDPVOL)	D(M1DEF)
CointEq1	0.031997	0.917712
	(0.00606)	(0.45197)
	[5.28013]	[2.03048]
D(GDPVOL(-1))	-0.310264	-8.883852
	(0.12653)	(9.43679)
	[-2.45216]	[-0.94141]
D(GDPVOL(-2))	-0.250381	-0.829902
	(0.12178)	(9.08257)

	[-2.05605]	[-0.09137]
D(M1DEF(-1))	0.003095	-0.068725
	(0.00162)	(0.12051)
	[1.91570]	[-0.57026]
D(M1DEF(-2))	0.002625	-0.096526
	(0.00171)	(0.12719)
	[1.53950]	[-0.75892]
C	0.959174	27.90645
	(0.16124)	(12.0259)
	[5.94868]	[2.32053]
R-squared	0.385828	0.072504
Adj. R-squared	0.342576	0.007187
Sum sq. resids	56.03423	311698.1
S.E. equation	0.888377	66.25794
F-statistic	8.920541	1.110037
Log likelihood	-97.02132	-429.0387
Akaike AIC	2.675878	11.29971
Schwarz SC	2.858513	11.48234
Mean dependent	0.707792	18.46150
S.D. dependent	1.095657	66.49734
Determinant Residual Covariance		3421.270
Log Likelihood		-525.5739
Log Likelihood (d.f. adjusted)		-531.8206
Akaike Information Criteria		14.17716
Schwarz Criteria		14.60330

Appendix B – Vector Auto Regression Tests on Causality (precedence)

Appendix Figure 4: Complete read out from the VAR test on CPI, Money Supply and Riksbank Reserves

Vector Autoregression Estimates

Sample(adjusted): 1837 1913

Included observations: 77 after adjusting endpoints

Standard errors in ( ) & t-statistics in [ ]

	DLOG(CPI)	DLOG(M1DEF)	DLOG(M2DEF)	DLOG(M3DEF)	DLOG(RBRESDEF)
DLOGCPI(-1)	0.505055	-0.675919	-0.187056	-0.197512	0.013963
	(0.12553)	(0.32616)	(0.31013)	(0.27080)	(0.75365)
	[4.02344]*	[-2.07237]*	[-0.60316]	[-0.72937]	[0.01853]
DLOGCPI(-2)	-0.179828	-0.033946	-0.071144	-0.075151	-1.353373
	(0.11820)	(0.30713)	(0.29203)	(0.25500)	(0.70968)
	[-1.52134]	[-0.11053]	[-0.24362]	[-0.29471]	[-1.90702]
DLOGM1DEF(-1)	0.242374	-0.424197	-0.393267	-0.331455	0.378014
	(0.08093)	(0.21028)	(0.19995)	(0.17459)	(0.48590)
	[2.99483]*	[-2.01728]*	[-1.96687]	[-1.89847]	[0.77797]
DLOGM1DEF(-2)	0.092010	-0.404555	-0.476446	-0.436789	-1.616502

	(0.08279)	(0.21511)	(0.20453)	(0.17860)	(0.49705)
	[1.11138]	[-1.88070]	[-2.32941]*	[-2.44565]*	[-3.25219]*
DLOGM2DEF(-1)	-0.235246	0.508077	0.684517	0.714533	1.624533
	(0.17475)	(0.45406)	(0.43174)	(0.37699)	(1.04920)
	[-1.34616]	[1.11896]	[1.58548]	[1.89535]	[1.54836]
DLOGM2DEF(-2)	-0.010351	0.502378	0.753044	0.716169	2.916830
	(0.17808)	(0.46271)	(0.43996)	(0.38417)	(1.06917)
	[-0.05813]	[1.08574]	[1.71161]	[1.86419]	[2.72812]*
DLOGM3DEF(-1)	0.236773	-0.613903	-0.545323	-0.586789	-2.123717
	(0.18869)	(0.49027)	(0.46617)	(0.40706)	(1.13287)
	[1.25482]	[-1.25217]	[-1.16979]	[-1.44154]	[-1.87463]
DLOGM3DEF(-2)	0.000233	-0.262593	-0.285237	-0.280705	-1.718486
	(0.18933)	(0.49193)	(0.46775)	(0.40844)	(1.13671)
	[0.00123]	[-0.53380]	[-0.60981]	[-0.68727]	[-1.51181]
DLOGRBRESDEF(-1)	0.005985	0.221332	0.121543	0.104796	0.058659
	(0.02297)	(0.05968)	(0.05675)	(0.04955)	(0.13791)
	[0.26055]	[3.70838]*	[2.14172]*	[2.11478]*	[0.42534]
DLOGRBRESDEF(-2)	-0.006199	0.118159	0.010979	-0.008273	-0.139690
	(0.02399)	(0.06232)	(0.05926)	(0.05174)	(0.14400)
	[-0.25846]	[1.89599]	[0.18529]	[-0.15988]	[-0.97004]
C	-0.003106	0.028164	0.035467	0.041023	0.026989
	(0.00613)	(0.01592)	(0.01514)	(0.01322)	(0.03678)
	[-0.50700]	[1.76936]	[2.34335]	[3.10403]	[0.73378]
R-squared	0.489402	0.291574	0.223869	0.251119	0.282417
Adj. R-squared	0.412038	0.184237	0.106273	0.137652	0.173693
Sum sq. resids	0.065506	0.442236	0.399829	0.304855	2.361241
S.E. equation	0.031504	0.081857	0.077833	0.067963	0.189146
F-statistic	6.326016	2.716426	1.903718	2.213146	2.597546
Log likelihood	162.9145	89.39086	93.27193	103.7132	24.89953
Akaike AIC	-3.945831	-2.036126	-2.136933	-2.408134	-0.361027
Schwarz SC	-3.611001	-1.701297	-1.802104	-2.073305	-0.026197
Mean dependent	0.005380	0.016714	0.044039	0.048666	0.011147
S.D. dependent	0.041086	0.090630	0.082331	0.073187	0.208079
Determinant Residual Covariance		1.15E-13			
Log Likelihood (d.f. adjusted)		600.8268			
Akaike Information Criteria		-14.17732			
Schwarz Criteria		-12.50317			

Appendix Figure 5: Residual Normality Tests

Orthogonalization: Cholesky (Lutkepohl)				
H0: residuals are multivariate normal				
Sample: 1834 1913				
Included observations: 77				
Component	Skewness	Chi-sq	df	Prob.
1	0.260182	0.868748	1	0.3513
2	-0.304470	1.189673	1	0.2754

3	0.333877	1.430585	1	0.2317
4	1.598821	32.80495	1	0.0000
5	-0.008145	0.000851	1	0.9767
Joint		36.29481	5	0.0000
Component	Kurtosis	Chi-sq	df	Prob.
1	2.131540	2.419797	1	0.1198
2	3.065657	0.013830	1	0.9064
3	2.700615	0.287567	1	0.5918
4	6.846068	47.45843	1	0.0000
5	1.741933	5.077934	1	0.0242
Joint		55.25756	5	0.0000
Component	Jarque-Bera	df	Prob.	
1	3.288545	2	0.1932	
2	1.203503	2	0.5479	
3	1.718152	2	0.4236	
4	80.26339	2	0.0000	
5	5.078785	2	0.0789	
Joint	91.55237	10	0.0000	

Appendix Figure 6: Test for Serial Correlation

VAR Residual Serial Correlation LM Tests

H0: no serial correlation at lag order h

Sample: 1834 1913

Included observations: 77

Lags	LM-Stat	Prob
1	17.00311	0.8817
2	21.79500	0.6476
3	21.17949	0.6826
4	20.96463	0.6946
5	51.24433	0.0015
6	32.13726	0.1541
7	45.79427	0.0068
8	28.74145	0.2749
9	25.76564	0.4202
10	31.19452	0.1827
11	22.96344	0.5797
12	27.51382	0.3307

Probs from chi-square with 25 df.

Appendix Figure 7: VAR test on CPI, Money Supply and Riksbank Reserves, 1834-1873 (Silver Standard).

Sample(adjusted): 1837 1873
Included observations: 37 after adjusting endpoints
Standard errors & t-statistics in parentheses

	DLOG(CPI)	DLOG(M1DEF)	DLOG(M2DEF)	DLOG(M3DEF)	DLOG(RBRESDEF)
DLOG(CPI(-1))	0.459713	-0.789539	-0.221404	-0.212514	0.998484
	(0.18592)	(0.54443)	(0.53687)	(0.46711)	(1.06878)
	(2.47267)*	(-1.45020)	(-0.41240)	(-0.45496)	(0.93423)
DLOG(CPI(-2))	-0.247281	-0.043396	-0.146659	-0.102237	-1.141393
	(0.17907)	(0.52439)	(0.51711)	(0.44992)	(1.02944)
	(-1.38088)	(-0.08275)	(-0.28361)	(-0.22724)	(-1.10875)
DLOG(M1DEF(-1))	0.280349	-0.282025	-0.526117	-0.366415	1.519916
	(0.18006)	(0.52729)	(0.51996)	(0.45240)	(1.03512)
	(1.55696)	(-0.53486)	(-1.01184)	(-0.80994)	(1.46835)
DLOG(M1DEF(-2))	-0.008705	-0.770717	-1.139886	-1.050876	-3.070226
	(0.18677)	(0.54692)	(0.53932)	(0.46924)	(1.07366)
	(-0.04661)	(-1.40919)	(-2.11356)*	(-2.23951)*	(-2.85958)*
DLOG(M2DEF(-1))	-0.397689	0.569096	0.831276	0.974372	0.818974
	(0.27840)	(0.81525)	(0.80392)	(0.69946)	(1.60042)
	(-1.42849)	(0.69806)	(1.03402)	(1.39302)	(0.51172)
DLOG(M2DEF(-2))	0.092611	0.891182	1.193747	1.280903	3.680434
	(0.28717)	(0.84094)	(0.82926)	(0.72151)	(1.65086)
	(0.32249)	(1.05974)	(1.43954)	(1.77532)	(2.22941)*
DLOG(M3DEF(-1))	0.318081	-1.058410	-0.875232	-1.089274	-2.655263
	(0.25574)	(0.74889)	(0.73849)	(0.64253)	(1.47015)
	(1.24378)	(-1.41330)	(-1.18517)	(-1.69529)	(-1.80611)
DLOG(M3DEF(-2))	0.027128	-0.282357	-0.184345	-0.300744	-1.153751
	(0.27095)	(0.79344)	(0.78242)	(0.68075)	(1.55761)
	(0.10012)	(-0.35586)	(-0.23561)	(-0.44178)	(-0.74072)
DLOG(RBRESDEF(-1))	0.016982	0.358471	0.270300	0.235449	0.311724
	(0.03990)	(0.11683)	(0.11521)	(0.10024)	(0.22936)
	(0.42564)	(3.06823)	(2.34615)*	(2.34886)*	(1.35913)
DLOG(RBRESDEF(-2))	-0.005013	0.122325	0.039041	-0.017746	-0.285356
	(0.04643)	(0.13598)	(0.13409)	(0.11666)	(0.26694)
	(-0.10796)	(0.89960)	(0.29116)	(-0.15211)	(-1.06900)
R-squared	0.583455	0.364859	0.369369	0.407774	0.428508
Adj. R-squared	0.423245	0.120574	0.126819	0.179995	0.208704

Appendix Figure 8: VAR test on CPI, Money Supply and Riksbank Reserves, 1874-1913 (Gold Standard)

Sample: 1874 1913
Included observations: 40
Standard errors & t-statistics in parentheses

	DLOG(CPI)	DLOG(M1DEF)	DLOG(M2DEF)	DLOG(M3DEF)	DLOG(RBRESDEF)
DLOG(CPI(-1))	0.139380	-0.387043	-0.542497	-0.229961	-2.468987
	(0.23304)	(0.54317)	(0.37046)	(0.30210)	(1.46242)
	(0.59811)	(-0.71256)	(-1.46438)	(-0.76121)	(-1.68829)
DLOG(CPI(-2))	0.393627	-0.235505	0.517276	0.222097	-1.257659
	(0.21660)	(0.50487)	(0.34434)	(0.28080)	(1.35931)
	(1.81726)	(-0.46646)	(1.50222)	(0.79095)	(-0.92522)
DLOG(M1DEF(-1))	0.316570	-0.429019	-0.060244	-0.085607	-0.078433
	(0.08199)	(0.19110)	(0.13034)	(0.10629)	(0.51451)
	(3.86122)*	(-2.24501)	(-0.46222)	(-0.80545)	(-0.15244)
DLOG(M1DEF(-2))	0.259840	-0.409347	-0.012236	-0.114383	-0.803059
	(0.09528)	(0.22209)	(0.15147)	(0.12352)	(0.59794)
	(2.72707)*	(-1.84318)	(-0.08078)	(-0.92603)	(-1.34304)
DLOG(M2DEF(-1))	1.097646	-0.626759	0.635186	-0.312780	-1.675661
	(0.46898)	(1.09312)	(0.74555)	(0.60797)	(2.94309)
	(2.34050)*	(-0.57337)	(0.85197)	(-0.51447)	(-0.56935)
DLOG(M2DEF(-2))	-0.741689	0.378830	0.268423	0.535720	7.222212
	(0.40868)	(0.95258)	(0.64969)	(0.52980)	(2.56470)
	(-1.81483)	(0.39769)	(0.41315)	(1.01117)	(2.81601)*
DLOG(M3DEF(-1))	-1.442504	0.658706	-0.797592	0.477402	1.338781
	(0.64231)	(1.49712)	(1.02109)	(0.83266)	(4.03081)
	(-2.24582)*	(0.43998)	(-0.78112)	(0.57334)	(0.33214)
DLOG(M3DEF(-2))	0.899027	-0.567413	0.111130	-0.304367	-7.126188
	(0.54217)	(1.26372)	(0.86190)	(0.70285)	(3.40241)
	(1.65820)	(-0.44900)	(0.12894)	(-0.43305)	(-2.09445)*
DLOG(RBRESDEF(-1))	0.026606	0.105057	0.025515	0.015744	-0.145594
	(0.02864)	(0.06675)	(0.04552)	(0.03712)	(0.17971)
	(0.92909)	(1.57395)	(0.56047)	(0.42409)	(-0.81017)
DLOG(RBRESDEF(-2))	0.007141	0.113968	-0.006682	0.001162	-0.134234
	(0.02596)	(0.06050)	(0.04126)	(0.03365)	(0.16289)
	(0.27511)	(1.88374)	(-0.16193)	(0.03452)	(-0.82407)
R-squared	0.611864	0.388137	0.256810	0.310863	0.466140
Adj. R-squared	0.478024	0.177149	0.000538	0.073229	0.282051

Appendix Figure 9: VAR test on Causality between the Monetary Base and different Money Supply measures

Sample(adjusted): 1837 1913				
Included observations: 77 after adjusting endpoints				
Standard errors & t-statistics in parentheses				
	DLOG(MBASEDEF)	DLOG(M1DEF)	DLOG(M2DEF)	DLOG(M3DEF)
DLOG(MBASEDEF(-1))	0.266340	0.115037	0.013939	0.037152
	(0.15387)	(0.12267)	(0.10776)	(0.09478)
	(1.73097)	(0.93775)	(0.12935)	(0.39198)
DLOG(MBASEDEF(-2))	-0.039195	0.149851	0.077718	0.030109
	(0.14889)	(0.11871)	(0.10427)	(0.09172)
	(-0.26324)	(1.26235)	(0.74532)	(0.32828)
DLOG(M1DEF(-1))	0.189004	-0.280256	-0.360762	-0.309932
	(0.27093)	(0.21600)	(0.18974)	(0.16689)
	(0.69762)	(-1.29748)	(-1.90139)	(-1.85713)
DLOG(M1DEF(-2))	-0.582646	-0.403142	-0.423008	-0.403614
	(0.28063)	(0.22374)	(0.19653)	(0.17286)
	(-2.07623)*	(-1.80187)	(-2.15238)*	(-2.33488)*
DLOG(M2DEF(-1))	0.541515	0.254739	0.634004	0.643862
	(0.60036)	(0.47865)	(0.42044)	(0.36981)
	(0.90199)	(0.53221)	(1.50794)	(1.74105)
DLOG(M2DEF(-2))	1.004013	0.639253	0.799186	0.746806
	(0.61790)	(0.49264)	(0.43273)	(0.38062)
	(1.62487)	(1.29762)	(1.84683)	(1.96207)
DLOG(M3DEF(-1))	-0.905861	-0.051759	-0.286690	-0.355129
	(0.64544)	(0.51459)	(0.45202)	(0.39758)
	(-1.40349)	(-0.10058)	(-0.63425)	(-0.89322)
DLOG(M3DEF(-2))	-0.380648	-0.478166	-0.456905	-0.405638
	(0.64756)	(0.51628)	(0.45350)	(0.39889)
	(-0.58782)	(-0.92618)	(-1.00750)	(-1.01692)
C	0.013651	0.011011	0.029140	0.035612
	(0.02080)	(0.01658)	(0.01457)	(0.01281)
	(0.65628)	(0.66391)	(2.00029)	(2.77931)
R-squared	0.142538	0.105410	0.163562	0.181084
Adj. R-squared	0.041660	0.000164	0.065157	0.084741
Sum sq. resids	0.878563	0.558449	0.430896	0.333364
S.E. equation	0.113666	0.090623	0.079603	0.070017
F-statistic	1.412971	1.001555	1.662135	1.879578
Log likelihood	62.96273	80.40803	90.39092	100.2712
Akaike AIC	-1.401629	-1.854754	-2.114050	-2.370681
Schwarz SC	-1.127678	-1.580803	-1.840098	-2.096730
Mean dependent	0.016045	0.016714	0.044039	0.048666
S.D. dependent	0.116111	0.090630	0.082331	0.073187
Determinant Residual Covariance		3.38E-11		
Log Likelihood		491.2444		
Akaike Information Criteria		-11.82453		
Schwarz Criteria		-10.72872		

Appendix Figure 10: Vector Auto Regression on Balance of Payments (BOPDEF) and Money Supply (M1DEF), (M2DEF), (M3DEF), 1834-1913. 1 lag, variables deflated by the Consumer Price Index

Sample(adjusted): 1836 1913				
Included observations: 78 after adjusting endpoints				
Standard errors & t-statistics in parentheses				
	BOPDEF	D(M1DEF)	D(M2DEF)	D(M3DEF)
BOPDEF(-1)	-0.131540	0.219091	0.492983	0.727992
	(0.11821)	(0.08862)	(0.30716)	(0.42503)
	(-1.11279)	(2.47237)*	(1.60498)	(1.71281)
D(M1DEF(-1))	0.115429	-0.220659	-1.573284	-2.119373
	(0.18096)	(0.13566)	(0.47021)	(0.65065)
	(0.63789)	(-1.62660)	(-3.34593)*	(-3.25733)*
D(M2DEF(-1))	0.009853	-0.189128	0.558760	0.031320
	(0.13310)	(0.09978)	(0.34585)	(0.47857)
	(0.07402)	(-1.89545)	(1.61559)	(0.06545)
D(M3DEF(-1))	0.043778	0.170193	0.158253	0.753409
	(0.09944)	(0.07455)	(0.25840)	(0.35755)
	(0.44024)	(2.28300)*	(0.61244)	(2.10712)*
C	-5.280886	7.748013	72.54861	113.0354
	(12.3206)	(9.23636)	(32.0148)	(44.3003)
	(-0.42862)	(0.83886)	(2.26610)	(2.55157)
R-squared	0.078877	0.141728	0.429800	0.425870
Adj. R-squared	0.028405	0.094700	0.398556	0.394410

Appendix Figure 11: Vector Auto Regression on Balance of Payments (BOPDEF) and Money Supply (M1DEF), (M2DEF), (M3DEF), Silver Standard, 1834-1873 Silver Standard. 1 lag, variables deflated by the Consumer Price Index

Sample(adjusted): 1837 1873				
Included observations: 37 after adjusting endpoints				
Standard errors & t-statistics in parentheses				
	D(BOPDEF)	D(M1DEF)	D(M2DEF)	D(M3DEF)
D(BOPDEF(-1))	-0.720332	0.180904	0.184776	0.242120
	(0.18526)	(0.08436)	(0.15228)	(0.17850)
	(-3.88827)*	(2.14454)*	(1.21340)	(1.35641)
D(BOPDEF(-2))	-0.221156	0.114159	0.052292	0.019871
	(0.18763)	(0.08543)	(0.15423)	(0.18078)
	(-1.17869)	(1.33621)	(0.33905)	(0.10992)
D(M1DEF(-1))	-0.222415	0.101424	-0.027606	-0.388453
	(0.90789)	(0.41340)	(0.74627)	(0.87477)
	(-0.24498)	(0.24534)	(-0.03699)	(-0.44406)
D(M1DEF(-2))	-2.731893	-0.698882	-1.673175	-1.935130
	(1.17327)	(0.53424)	(0.96441)	(1.13047)
	(-2.32845)*	(-1.30819)	(-1.73492)	(-1.71179)
D(M2DEF(-1))	1.135719	0.075000	-0.718792	-0.571516
	(1.32149)	(0.60173)	(1.08625)	(1.27329)
	(0.85942)	(0.12464)	(-0.66172)	(-0.44885)
D(M2DEF(-2))	1.158251	0.659572	1.006682	1.551423
	(1.45525)	(0.66263)	(1.19620)	(1.40216)

	(0.79591)	(0.99538)	(0.84157)	(1.10645)
D(M3DEF(-1))	-1.196840	-0.241179	0.460389	0.597879
	(1.11227)	(0.50646)	(0.91427)	(1.07169)
	(-1.07604)	(-0.47621)	(0.50356)	(0.55788)
D(M3DEF(-2))	0.341587	-0.015319	0.330799	0.088305
	(1.01305)	(0.46128)	(0.83271)	(0.97609)
	(0.33719)	(-0.03321)	(0.39725)	(0.09047)
R-squared	0.475553	0.266201	0.382786	0.468645
Adj. R-squared	0.325712	0.056544	0.206439	0.316829

Appendix Figure 12: Vector Auto Regression on Balance of Payments (BOPDEF) and Money Supply (M1DEF), (M2DEF), (M3DEF), Gold Standard, 1874-1913. 1 lag, variables deflated by the Consumer Price Index

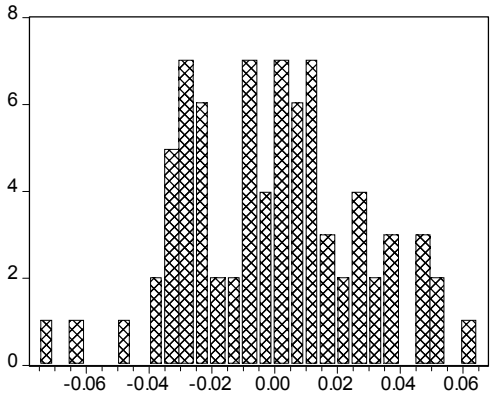
Sample: 1874 1913				
Included observations: 40				
Standard errors & t-statistics in parentheses				
	D(BOPDEF)	D(M1DEF)	D(M2DEF)	D(M3DEF)
D(BOPDEF(-1))	-0.609217	0.081466	0.019577	0.026396
	(0.15956)	(0.15152)	(0.61040)	(0.82588)
	(-3.81818)*	(0.53766)	(0.03207)	(0.03196)
D(BOPDEF(-2))	-0.358289	0.043203	0.203052	0.345616
	(0.16151)	(0.15338)	(0.61788)	(0.83599)
	(-2.21836)*	(0.28168)	(0.32863)	(0.41342)
D(M1DEF(-1))	0.219384	-0.223622	-0.969612	-1.227726
	(0.23168)	(0.22001)	(0.88631)	(1.19919)
	(0.94693)	(-1.01642)	(-1.09398)	(-1.02380)
D(M1DEF(-2))	-0.189144	-0.430006	-0.293961	-1.488808
	(0.21376)	(0.20299)	(0.81776)	(1.10644)
	(-0.88484)	(-2.11833)	(-0.35947)	(-1.34559)
D(M2DEF(-1))	-0.026997	-0.185400	0.995339	0.378444
	(0.14679)	(0.13939)	(0.56155)	(0.75978)
	(-0.18392)	(-1.33006)	(1.77249)	(0.49810)
D(M2DEF(-2))	0.083202	-0.052635	-0.414915	-0.312738
	(0.15508)	(0.14727)	(0.59328)	(0.80271)
	(0.53650)	(-0.35741)	(-0.69936)	(-0.38960)
D(M3DEF(-1))	0.038293	0.127923	-0.461418	-0.034255
	(0.11301)	(0.10732)	(0.43233)	(0.58494)
	(0.33885)	(1.19203)	(-1.06729)	(-0.05856)
D(M3DEF(-2))	-0.070653	0.108898	0.570985	0.769604
	(0.11923)	(0.11322)	(0.45612)	(0.61714)
	(-0.59258)	(0.96180)	(1.25182)	(1.24706)
R-squared	0.450242	0.217460	0.345865	0.320863
Adj. R-squared	0.308368	0.015515	0.177056	0.145602

Appendix C – Tests of the OLS-model determining price changes

Appendix Figure 13: Complete Read out of OLS Regression Determining Price Changes

Dependent Variable: DLOG(CPI)				
Method: Least Squares				
Sample(adjusted): 1836 1913				
Included observations: 78 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000148	0.004142	0.035695	0.9716
DLOG(M1DEF(-1))	0.208837	0.038308	5.451567	0.0000
DLOG(CPI(-1))	0.431343	0.082337	5.238730	0.0000
DLOG(GDPVOL)	-0.136901	0.103992	-1.316460	0.1921
DLOG(GERCPI)	0.176576	0.038591	4.575629	0.0000
R-squared	0.545961	Mean dependent var		0.005182
Adjusted R-squared	0.521083	S.D. dependent var		0.040856
S.E. of regression	0.028274	Akaike info criterion		-4.231804
Sum squared resid	0.058357	Schwarz criterion		-4.080733
Log likelihood	170.0404	F-statistic		21.94482
Durbin-Watson stat	2.148764	Prob(F-statistic)		0.000000

Appendix Figure 14: Distribution of Residuals, Histogram Normality Test on the OLS Regression Determining Price Changes



Series: Residuals	
Sample 1836 1913	
Observations 78	
Mean	-1.76E-18
Median	0.001667
Maximum	0.063584
Minimum	-0.072907
Std. Dev.	0.027530
Skewness	0.002068
Kurtosis	2.818825
Jarque-Bera	0.106734
Probability	0.948032

Appendix Figure 15: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.821904	Probability	0.367648
Obs*R-squared	0.880346	Probability	0.348107

Appendix Figure 16: White Heteroskedasticity Test (including cross-terms)

F-statistic	0.939496	Probability	0.523139
Obs*R-squared	13.47196	Probability	0.489744

Appendix Figure 17: Ramsey RESET Test (general stability and specification test)

F-statistic	0.332781	Probability	0.565825
Log likelihood ratio	0.359682	Probability	0.548683

Appendix Figure 18: Testing for multicolinearity (Correlations between independent variables)

	DLOG (M1DEF(-1))	DLOG (GDPVOL)	DLOG (GERCPI)	DLOG (CPI(-1))
DLOG(M1DEF(-1))	1.000000	0.175461	0.174360	-0.260304
DLOG(GDPVOL)	0.175461	1.000000	-0.212240	-0.136634
DLOG(GERCPI)	0.174360	-0.212240	1.000000	0.057755
DLOG(CPI(-1))	-0.260304	-0.136634	0.057755	1.000000

Multicolinearity does not seem to be a problem in the model, and thus it is questionable whether changes in GDP has any impact on changes in prices