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Policing the chain gang: Panel cointegration analysis of the stability of the Suffolk System, 1825–1858

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ABSTRACT

Conventional monetary theory suggests that a closed system banking regime may lead to in-concert overexpansions of circulation by its banks. However, Selgin (2001, 2010) argues that this is unlikely as long as there are enough banks to ensure (i) routine interbank settlement and (ii) no collusion amongst banks refraining from redeeming one another's notes. Banks effectively form a "chain gang" where in-concert expansion requires coordination that is prohibitively costly in a system with many banks. In order to test this conjecture, we examine state-level data on circulations and reserves from the Suffolk Banking System (1825–1858) in New England. In addition to narrative evidence on the stability of the Suffolk, panel cointegration tests provide evidence of a long-run relationship between state-level circulations and total reserves. The estimated error-correction mechanisms suggest a deviation half-life of about 2 years. We argue that a cointegrating relationship between circulations and reserves, along with rapid error-correction, supports the Selgin hypothesis.

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1. Introduction

Can a private, interbank clearing institution (or institutions) provide a feasible basis for a stable monetary order? One of the greatest concerns involves the possibility of unlimited expansion of banks' liabilities (Goodhart, 1988; Laidler, 1992; Bordo and Schwartz, 1996). Specifically, researchers have argued that such a clearinghouse will be unable to prevent over-issue by banks acting in concert. Although such an institution may provide a check on the note issue of an individual bank through "adverse clearings" (Selgin, 1988, p. 40) it may not be able do the same when banks expand uniformly (Bordo and Schwartz, 1996; Gorton, 1985; Gorton and Mullineaux, 1987). If such a clearing institution cannot prevent an in-concert overexpansion of notes then this inability represents a critical weakness in the free banking school of thought (e.g., Hayek, 1978; Glasner, 1989; White, 1989; Dowd, 1993; Selgin and White, 1994).

Adverse clearings work in the following way to check individual bank note issue in a system based on a stock of outside money (traditionally specie). When an individual bank issues notes disproportionately, its debits in the clearinghouse begin to exceed its credits. As system debits and credits are settled via specie flows, the over-expanding bank finds itself drained of reserves and forced to contract its balance sheet or fail. As Goodhart (1988) argues, the clearinghouse mechanism creates a

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tendency for banks to increase or decrease issue in unison. The problem, however, is that this tendency may persist and each bank's credits and debits in the clearinghouse will increase in step during an overexpansion.

Selgin (1988, 1994, 2001), on the other hand, argues that the clearinghouse mechanism also provides a check on in-concert overexpansion. According to Selgin (2001, p. 294), the "'in-concert overexpansion' doctrine is inconsistent with standard theories of the precautionary demand for bank reserves." An in-concert overexpansion "will involve changes in the *variance* of each banks' daily net reserve loss, so that, although the expected value of that loss may not increase, its realized value will increase for roughly half of all clearing sessions" (Selgin, 2001, p. 297). The increased variance of adverse clearings will result in an increased demand for precautionary reserves, checking the in-concert expansion. Selgin (2010, p. 488) likens banks operating in such a system to members of a chain gang. They can only move forward if they do so in unison, coordinating their steps. Such coordination, however, becomes increasingly difficult because of the increase in precautionary reserve demand.

The purpose of this paper is to formally evaluate the in-concert overexpansion doctrine using data from the Suffolk System (1825–1858). The Suffolk was a private clearinghouse system that served New England banks. Numerous authors have cited it as a successful case of self-regulation (e.g., Mullineaux, 1987; Dowd, 1994; Calomiris and Kahn, 1996) but this view is controversial. For example, Lake (1947, p. 1907) early on expressed the view that the Suffolk "protect[ed] the public against overissue by individual banks, but not against overissue by the system." The Suffolk, then, provides a unique historical experiment to ask whether in-concert overexpansion is likely to occur under a private, interbank clearinghouse arrangement.

We examine a panel of state-level data on banks' note issues and specie stocks under the Suffolk using panel cointegration techniques and the estimation of an error correction models. We find that the unit root null cannot be rejected for specie stocks. For note issues, of the eight unit root tests conducted only one rejects the null. Conditional on the nonstationarity of these series, we also present evidence that state-level note issues are cointegrated with both the corresponding state-level specie stocks and the aggregate (Suffolk-wide) stock of specie. Estimation of the error-correction mechanism suggests an annual adjustment rate to deviations from the long-run relationship with aggregate specie of about 46%. We conclude that the available data do not lend support to the in-concert overexpansion doctrine. In particular, our findings are consistent with the image conjured by Selgin (2010): New England banks constituted a "chain gang" of whose circulations the Suffolk System effectively policed during the 1825–1858 time period.[1]

2. A brief history of the Suffolk clearinghouse system

The Suffolk System was one of the first attempts at creating a banknote clearinghouse within the US.[2] In the early 1800s, due to branch banking restrictions, redemption of note issue was very costly; especially for the notes of country banks (Dowd, 1994).[3] Banknote brokers made a living buying country banknotes (at a discount) and then redeeming them. In 1818 the Suffolk bank entered the note brokerage market, purchasing country banknotes at a discount typically of 1% or less.[4] Country banks could then redeem the notes at that same discount with the Suffolk Bank which profited by requiring participating country banks to maintain a non-interest deposit of $5000.

Over the next 2 years, competition led to discounts on country notes of about one half of one percent. In response to this squeeze on its profit margins, the Suffolk briefly withdrew from the note brokerage market. However, in 1824 the Suffolk and six other large Boston city banks attempted to drive country banknotes out of circulation in the city. The city banks accumulated large numbers of country banknotes through purchases and then returned them to the country banks, *en masse*, for redemption (Rolnick et al., 1998).

Although this plan proved unsuccessful it paved the way for the introduction of a clearinghouse system. In May of 1825 the other coalition banks endorsed country banks depositing their notes with the Suffolk. However, instead of sending the notes back for redemption the Suffolk would act as a clearinghouse for participating banks. All deposits of the notes of participating banks would be cleared through debits and credits to the banks' accounts. By 1826 several Boston banks, including a majority of the coalition banks and New England banks generally, had become part of the Suffolk System.

Under this new system participating country banks each maintained a non-interest-bearing deposit at the Suffolk Bank of $2000 for every $100,000 of their capital. The required deposit for participating city banks was $5000 for every $100,000 of capital. Country banks were additionally required to hold a separate non-interest-bearing deposit as a redemption fund.

Although the Suffolk Bank remained the clearinghouse for New England banks through 1858, the beginning of the end began in 1855 with the chartering of the Bank of Mutual Redemption (BMR). By 1858 the BMR had raised enough capital to begin operations and immediately began competing directly with the Suffolk Bank. Along with this competition the Suffolk faced political pressure from Massachusetts bank commissioners to retreat from its dominant position in the market. Furthermore, fueled by country banks that had never gotten over "the indignity of what can only be characterized as a bank

[1] In this context, "policing" amounts to the facilitation of redemptions of notes and the flow of reserves across banks in the clearinghouse system.

[2] For a full and comprehensive account of the history of the Suffolk Bank and the Suffolk System see Whitney (1878). A more concise overview is found in Rolnick et al. (1998). Several basic facts are presented without citation in this section; they are drawn largely from these two sources.

[3] Boston banks actually referred to notes issued by country banks as "foreign money" (Rolnick et al., 1998, p. 12).

[4] The Suffolk was the second Boston bank to enter this market, the first being the New England Bank in 1814.

run orchestrated by the Suffolk Bank" (Bodenhorn, 2002, p. 148), popular sentiment turned against the Suffolk. As a result the Suffolk Bank had completely exited the market for note-clearing services by 1860.[5]

Although it effectively ended in 1858, the Suffolk System provides 33 years of data with which to evaluate the in-concert overexpansion doctrine vis-à-vis Selgin's (1988, 1994, 2001, 2010) "chain gang" alternative. Selgin associates the following characteristics with a clearinghouse system not prone to in-concert overexpansion: (1) interbank settlements are frequent; (2) banks do not have an incentive to hold negative balances with other member banks; (3) the lending rate on interbank overnight loans is a penalty rate; (4) banks are numerous enough that deliberate collusion amongst them is prohibitively difficult. Given this, the relevant question is whether the Suffolk System was characterized by (1), (2), (3) and (4).

Between 1825 and 1831 the Suffolk System cleared bank notes with its member banks on a weekly basis. However, by 1831 the volume of notes received had increased to such an extent that the Suffolk had moved to daily clearing operations (Calomiris and Kahn, 1996, p. 775). For the entire time period clearing operations were reasonably rapid and sophisticated. In 1825 the Suffolk Bank was receiving $2 million a month in country notes; increasing to almost $9 million by 1841, $20 million in 1851, and $30 million at its peak in 1858 (Trivoli, 1979, pp. 14 and 21). As Rolnick et al. (1998, p. 41) point out, these numbers correspond to almost half of the total circulation in Massachusetts in 1825; all of the notes in circulation in 1841 and 1851; and almost one-and-a-half times the circulation by 1858.

Also, the Suffolk had a range of penalties for banks that maintained negative balances with it (Dowd, 1994). An initially depleted (or continuously low) balance first resulted in "moral suasion" whereby the offending bank would be reminded of its need to maintain deposits with the Suffolk Bank. If the situation persisted the Suffolk would either severely limit that bank's overdraft guarantee or begin sending the offending bank's notes back for redemption (charging interest until redemption occurred).[6] As a last resort the Suffolk could expel the offender from the system (Mullineaux, 1987, p. 891). As Calomiris and Kahn (1996, pp. 773–774) point out, membership within the Suffolk System was an important signal to the public. A bank in good standing was perceived as ready and able to meet its obligations, while expulsion from the Suffolk led to an immediate discounting of a bank's notes (Lake, 1947, p. 190).

Lake (1947) and Rolnick et al. (1998) both suggest that the Suffolk's overnight lending rate was a penalty rate. The *Banker's Magazine and Statistical Register* (April, 1885; pp. 724) reports that when the deposits of a member bank were insufficient to meet its obligations, the Suffolk would loan the bank the necessary funds on a short-term basis. *Hunt's Merchants' Magazine and Commercial Review* (Sept., 1841; pp. 261) states that the rate charged for this overnight lending was, "perhaps seven or eight per cent per annum." Given that the legal usury rate of interest was 6% in the state of Massachusetts, it would seem that the overnight rate was indeed a penalty rate.

Lastly, there is the concern that banks may collude to refrain from redeeming one another's notes. However, with a sufficient number of banks, such collusion would be prohibitively difficult to coordinate. By 1836 over 300 banks were members of the Suffolk System (Rolnick et al., 1998, p. 14). Therefore, it would appear reasonable to conclude that collusion between banks would be extremely difficult to maintain.

3. Data and empirical models

We have established that the Suffolk provided a good approximation to the type of banking system described by Selgin (1988, 1994, 2001). Now we describe the data from the Suffolk System that we use to evaluate the Selgin hypothesis. We then outline the unit root and cointegration tests that we employ; also the error-correction models that we estimate.

Our hypotheses are as follows. Individual banks cannot expand their note issues alone; their notes outstanding should be cointegrated with their reserves (specie stocks). Furthermore, deviations from that long-run relationship should be corrected reasonably soon. Thus banks together constitute a "chain gang" where overexpansion is only possible if all banks expand in-concert. However, even in-concert expansion is unlikely to occur because the variance (though not the mean) of net reserve losses increases. As the variance increases, so will precautionary reserve demands. Consistent with this reasoning, banks' note issues will also be cointegrated with the aggregate (clearinghouse system-wide) stock of specie.

3.1. Data

We begin with data compiled for New England banks from Weber (2008).[7] This dataset provides the most accurate and concise series of individual bank statements available. Data from *Hunt's Merchants' Magazine and Commercial Review* and the Comptroller of the Currency's Report of 1876 are used to fill missing or incomplete observations in the Weber (2008) data.[8]

[5] Ironically, the BMR turned out not to be a profitable operation (Rolnick et al., 1998, p. 15).

[6] As an example, Whitney (1878, p. 17) notes that both The Phoenix and Pacific Banks, were forced to pay 2% interest per month, on failure to redeem their notes outstanding, until redemption was met.

[7] This data are freely available at http://research.mpls.frb.fed.us/research/economists/wewproj.html.

[8] These two sources were generally used to check the validity of the aggregated data from the Weber (2008) datasets. Although only minor discrepancies were detected (i.e. differences within hundreds of dollars) subsequent changes to the aggregated data used here were made such that the most contemporary data available to the times were employed. For example, when a discrepancy was detected, if the Comptroller's Report provided a different data point, then that information was employed. If both *Hunt's* and the Comptrollers Report provided two different data points, then the information from *Hunt's* was employed. Further, the inclusion of this data also allowed us to fill in some of the missing annual aggregate data found in the Weber (2008) dataset for various states.

Table 1
Summary statistics for note issues and specie stocks (thousands of dollars) and reserve ratios (specie divided by notes) under the Suffolk, 1825–1858.

	MA	VT	NH	CT	RI	ME	Total
Notes							
Mean	12,574	2415	1702	5084	2281	2611	29,716
Std. dev.	6700	1127	870	2733	1318	1326	12,849
Maximum	26,544	4764	3678	11,220	5522	5318	53,990
Minimum	4091	848	685	1921	675	1106	15,198
Specie							
Mean	2826	130	259	607	392	452	5266
Std. dev.	2053	48	156	296	108	295	2369
Maximum	11,092	209	790	1207	733	1164	13,830
Minimum	902	51	127	1186	243	137	2289
Reserve ratio							
Mean	0.235	0.058	0.187	0.127	0.231	0.167	0.192
Std. dev.	0.132	0.019	0.132	0.050	0.133	0.044	0.089
Maximum	0.791	0.109	0.475	0.279	0.506	0.252	0.518
Minimum	0.117	0.035	0.056	0.048	0.062	0.089	0.118
First year	1825	1834	1829	1834	1825	1834	1834
No. of Years	34	25	30	25	34	25	25

Note: "Total"s refer to the statistics associated with aggregate notes and specie; not the sums or averages of the state column numbers.

We aggregate the individual banks' data into state-level data for Massachusetts, Connecticut, Vermont, New Hampshire, Rhode Island and Maine. This constitutes an unbalanced panel of data on specie stocks and notes outstanding from 1825 to 1858 ($T \leqslant 34$; $N = 6$).

We aggregate to the state-level because (i) we want to examine note issue in relation to reserves *system*-wide and (ii) panel unit root tests and some panel cointegration tests require allowance of a reasonable number of lagged observations. Although total specie and circulation for Massachusetts is available from 1825 to 1858, for the other states this is not necessarily the case. In some cases only a single year of missing data created a gap in an otherwise continuous series. In these, and only these, cases we substituted in the average of the adjacent yearly values. This interpolation was applied to Vermont's 1835 specie stock; Connecticut's 1835 specie stock; and Rhode Island's 1836 note issue and specie stock.[9] As a result, all state-level series begin at 1834 or earlier (MA in 1825; VT in 1834; NH in 1829; CT in 1834; RI in 1825; ME in 1834).

A limitation of our data is that it is impossible to determine exactly which banks were members of the Suffolk. However, Calomiris and Kahn (1996) note that in 1825 the majority of New England banks were already members. Furthermore, by 1836 there were almost 300 member banks – nearly all New England banks (Rolnick et al., 1998, p. 14). By 1838 there were over 300 member banks (Trivoli, 1979, p. 14). Also, since the Suffolk promptly returned notes from nonmember banks for redemption, it is reasonable to assume that all New England banks were affected by the Suffolk's standards and practices.[10]

Table 1 presents summary statistics for our time series. Total specie and note series are calculated starting in 1834, the first year for which there are data for all states. Summary statistics for notes and specie are for thousands of dollars although natural logs are taken for both notes and specie series in the econometric analysis. Fig. 1 plots the time series of the logged note and specie values for each state and Fig. 2 plots the state-level reserve ratios (specie divided by notes). Augmented Dickey–Fuller (ADF) unit root tests for each of the state-level specie and notes series are reported in Table 2. Test results are reported for specifications with both two and four lags; trends and intercept terms are included. In no case can the unit root null hypothesis be rejected at the 5% significance level or better. For the case of Rhode Island the null for the note issues can be rejected but only at the 10% significance level; the same is true for Vermont specie stocks, but only based on the four-lag specification.

Strictly speaking, Selgin's theory implies a stable relationship between specie stocks and *the product of note issues and velocity* (i.e., nominal spending). In general reserve demand will be increasing in velocity. If notes issued into circulation are expected to return very quickly then, all else equal, banks will want to hold greater reserves on hand to provide for their redemption. Alternatively, if notes put into circulation are likely to remain in circulation for a long time, banks can profit in the interim by loaning out a greater part of the funds.[11] In terms of available data, the product of notes and velocity corresponds to *note redemptions*. Focusing instead on note issues may lead us to incorrectly reject the chain gang

[9] For Vermont, although data on circulation is available as far back as 1827, subsequent specie data is not available. State banking reports at the time lumped specie into a category with various other assets of each bank. For New Hampshire, the missing data are attributable to the fact that no banking commission had been established within the state at that time. As such, statewide bank audits were only made by special request of the legislature; apparently no such requests were ever made for those 2 years.

[10] Legislation in Vermont and Massachusetts, passed in 1842 and 1843, respectively, created a strong set of incentives for their banks to enter the Suffolk System. Specifically, Vermont taxed any nonmember bank 10% on its operating capital. Massachusetts prohibited any state bank from paying out the notes of other banks, thus effectively requiring that all notes be cleared through the Suffolk System. We also know from Knox (1900, p. 333) that by1848 there were only two banks in the Maine that did not maintain accounts with the Suffolk.

[11] In the extreme, if velocity were to plummet towards zero then note issue could increase to some arbitrarily large number without any of the new notes finding their way back to the clearinghouse (and, in turn, becoming part of the net demand for any bank's reserves). In this scenario, neither adverse clearings nor the variance net reserve losses would necessarily increase.

Fig. 1. State-level note issues and specie stocks under the Suffolk. Solid lines are note issues; broken lines are specie stocks.

hypothesis if, for example, we observe note issues persistently rising (relative to specie) while velocity persistently falls. Alternatively, we may incorrectly accept the hypothesis if we observe note issues falling while velocity rises more than proportionately.

We can consider these possibilities by examining annual data on Suffolk note redemptions.[12] These data are only for the aggregate, 1834–1858, which means that observations are two few to employ the panel unit root and cointegration tests. However, Fig. 3 plots (the logs of) aggregate Suffolk redemptions and note issues. The two series have very similar trends throughout most of the period. In 1854 the most notable divergence occurs. Redemptions increase markedly to a plateau while note issues contract, implying a period of decreasing money demand (increasing velocity) and a contracting money supply. However, the contraction in notes is initially insufficient to prevent the ratio of redemptions to reserves from increasing. Fig. 4 plots logged redemptions net of logged total specie reserves in the Suffolk. Starting from a value of 3.07 in 1854, the series increases substantially to 3.49 in 1855. It then levels off by 1856 and afterwards falls. By 1858 it has returned to a value of 3.18, very close to its 1854 value.

What can we conclude from Figs. 3 and 4? On the one hand, the post-1854 contraction of notes is muted and/or delayed relative to the increase in redemptions. On the other hand, by 1856 the ratio of redemptions to specie is falling and,

[12] Data are from Trivoli (1979) for 1841 to 1842 and then 1844 to 1858; Knox (1900) for 1841 to 1857; and *Hunt's Merchants' Magazine* (March 1852) for 1834 to 1850. Data are in agreement at dates of overlap across sources.

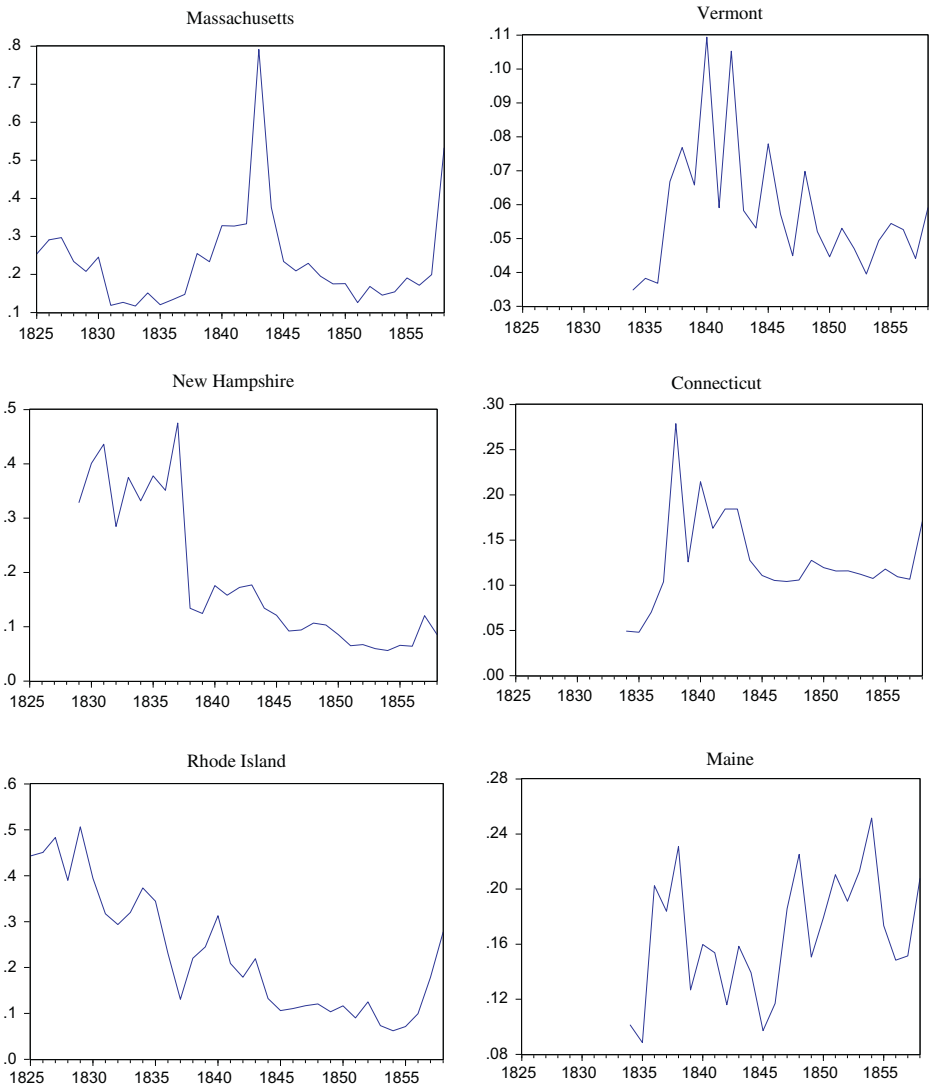

Fig. 2. State-level reserve ratios (specie divided by notes) under the Suffolk.

Table 2
Unit root tests on (logs of) state-level note issues and state-level specie stocks.

	Notes		Specie	
	ADF statistic (2 lags)	ADF statistic (4 lags)	ADF statistic 2 lags)	ADF statistic (4 lags)
MA	−2.564	−2.638	−1.766	−2.491
VT	−1.799	−2.773	−2.659	−3.348*
NH	−1.741	−1.787	−1.147	−0.718
CT	−1.975	−2.216	−2.916	−2.613
RI	−3.248*	−3.555*	−1.250	−0.307
ME	−2.748	−1.598	−2.084	−2.022

Notes: all tests include trends and intercepts. Null hypothesis is a unit root(s).
** Rejection at the 5% significant level.
*** Rejection at the 1% significant level.
* Rejection at the 10% significant level.

between 1857 and 1858, it has almost returned to its starting value (while, notably, redemptions were again rising). We believe that the data are consistent with the chain gang hypothesis. However, the full adjustment of note issues appears to lag behind changes in velocity by a couple of years or more. Figs. 3 and 4 suggest a lag length similar to the two-and-a-half

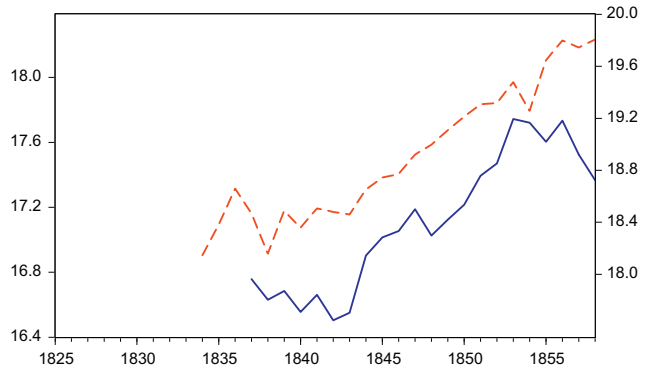

Fig. 3. Suffolk (logs of) total note issues and note redemptions. Solid lines are note issues; broken lines are specie stocks.

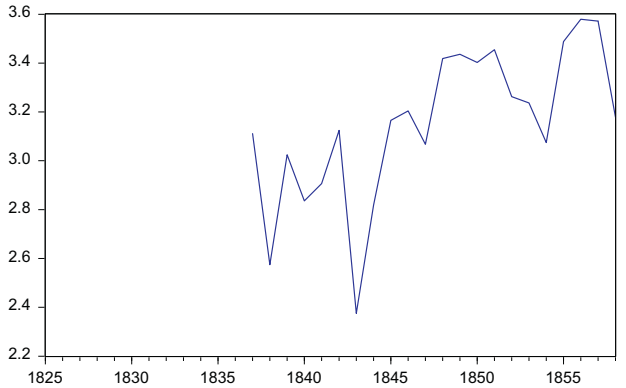

Fig. 4. Suffolk (log of) total redemptions minus (log of) total specie stock.

years that we report based on the estimation of error-correction models for notes adjusting to specie stocks.[13] (See Section 3.4 below.)

Despite state-level redemption or velocity data being unavailable, we believe that there is value to proceeding with a state-level analysis of note issues and specie stocks. There is no doubt that a clearinghouse system's ability to respond to changes in money demand is a critical element of its overall effectiveness. However, another critical element is a constraint on banks' expansion of note issues, singly or in-concert, that is provided by the system's facilitation of the prompt presentation and redemption of notes. In the absence of large changes in velocity, such a constraint should manifest itself in a cointegrating relationship between note issues and specie stocks. Again, one expects that reserve demand varies generally and positively with velocity. However, we observe that the log of velocity stayed in the range of 2.375–3.580 between 1834 and 1857 (Fig. 4). Given different policies and economic conditions across the New England states – and the levels and variances of net reserve losses across the Suffolk System – our state-level panel of notes and reserves can be informative about that cointegrating relationship.

3.2. Panel unit root tests

The small number of observations for each state implies that the power of the ADF tests reported in Table 2 is very low. Also, we are interested in looking at the properties of note issues and reserves in the Suffolk *System* considered as a whole. Therefore we will report the results of panel unit root tests.

We first consider a widely-used test introduced by Levin et al. (2002). This test is straightforward; based on an ADF test. The specification is,

$$\Delta y_{it} = \alpha y_{i,t-1} + \sum_{j=1}^{p} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it}, \tag{3.1}$$

[13] If we perform an ADF test on the aggregate ratio of redemptions to specie it fails to reject the presence of a unit root. (This is true regardless of the lag length chosen.) This is not surprising (or very informative) given the low-power of ADF tests and the maximum of 24 observations.

where i denotes the cross-section unit, t is the time period and, in this context, the y_{it}s are the (logs of) notes and specie series.[14] The error term is denoted by ε_{it}. The null hypothesis is that there is a unit root ($\alpha = 0$) and the alternative is one-sided ($\alpha < 0$). Levin et al. (2002) recommend replacing y_{it} and Δy_{it} with measures free of deterministic components and serial correlation. This is achieved by, for each cross-section, regressing both y_{it} and Δy_{it} on p lags of Δy_{it}. The resulting estimated coefficient vectors are $\hat{\lambda}_i$ and $\hat{\theta}_i$ respectively. Next, define the variables,

$$\bar{y}_{i,t-1} = y_{i,t-1} - \sum_{j=1}^{p} \hat{\lambda}_{ij} \Delta y_{i,t-j};$$

$$\Delta \bar{y}_{it} = \Delta y_{it} - \sum_{j=1}^{p} \hat{\theta}_{ij} \Delta y_{i,t-j}.$$

These two measures are then standardized by dividing by the standard error from a regression of (3.1), for each cross-section (denoted by $\hat{\sigma}_i$), using the unmodified data on y_{it} and Δy_{it}:

$$\bar{y}^*_{i,t-1} = \bar{y}_{i,t-1} / \hat{\sigma}_i; \tag{3.2}$$

$$\Delta \bar{y}^*_{it} = \Delta \bar{y}_{it} / \hat{\sigma}_i. \tag{3.3}$$

Finally, the panel unit root test statistic is based on a pooled regression using the modified variables defined by (3.2) and (3.3):

$$\Delta \bar{y}^*_{it} = \alpha \bar{y}^*_{i,t-1} + \eta_{it}. \tag{3.4}$$

While Levin et al.'s (2002) test provides a solid baseline, we also utilize a test proposed by Im et al. (2003). This test is also based on a conventional ADF test but, unlike Levin et al.'s (2002) test, allows for cross-section unit-specific roots. Specify for each cross-section unit, i,

$$\Delta y_{it} = \alpha_i y_{i,t-1} + \sum_{j=1}^{p} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it}, \tag{3.5}$$

The null hypothesis is that there is a unit root ($\alpha_i = 0$ for all i). A separate OLS regression of (3.5) for each cross-section unit is run. The panel test statistic is then based on the average of t-statistics from the cross-section unit ADF tests.

Lastly, we report the results of the test suggested by Maddala and Wu (1999). Based on Fisher (1932) methodology, Maddala and Wu consider the following test statistic using the p-values of individual (here, for state-level series) ADF tests:

$$-2 \sum_{i=1}^{N} \log(p_i), \tag{3.6}$$

where the p_i are the p-values from the individual ADF tests. Maddala and Wu show that this statistic has an asymptotic chi-squared distribution with $2N$ degrees of freedom.

3.3. Panel cointegration tests

We examine the possibility of cointegration, conditional on notes and specie series being non-stationary, using the test statistics described in Pedroni (1999, 2004). Perdoni's tests are derived from the Engel and Granger (1987) cointegration test; based on the following model:

$$y_{1,it} = \varphi_i y_{2,it} + \varepsilon_{it}, \tag{3.7}$$

where $y_{1,it}$ and $y_{2,it}$ are both assumed to be integrated of order one. In the absence of cointegration, the error term (ε_{it}) from (3.7) is non-stationary.

Consider the following model of the residuals from an estimation of (3.7):

$$\hat{\varepsilon}_{it} = \alpha_i \hat{\varepsilon}_{i,t-1} + \sum_{j=1}^{p} \beta_{ij} \hat{\varepsilon}_{i,t-j} + v_{it}. \tag{3.8}$$

The relevant null is $\alpha_i = 1$ and corresponds to no cointegration between $y_{1,it}$ and $y_{2,it}$. Pedroni derives several test statistics associated with this null. We report results based on all of them below.

[14] Constants and time trends are suppressed in the exposition of all tests in this section. However, they are included in the actual tests reported on in Section 4.

Table 3
Panel unit root tests on (logs of) note issues, specie stocks, and reserve ratios.

	Test statistics		
	Notes	Specie	Reserve ratio
ADF (Levin et al. (2002))			
2 lags	1.489	2.346	0.137
4 lags	2.733	4.179	3.857
ADF (Im et al. (2003))			
2 lags	−0.739	0.357	−1.685**
4 lags	−1.173	0.444	−0.309
Fisher-ADF (Maddala and Wu (1999))			
2 lags	12.652	8.332	19.177*
4 lags	14.347	10.305	9.627

Notes: all tests include trends and intercepts. Null hypothesis is always a unit root(s).
*** Rejection at the 1% significant level.
* Rejection at the 10% significant level.
** Rejection at the 5% significant level.

3.4. Error-correction model

We argue that cointegration of note issues and reserves constitutes evidence against the in-concert overexpansion doctrine. In-concert overexpansion implies that a "chain gang" of banks, acting together, can "escape" from the constraint provided by the clearinghouse. Alternatively, cointegration implies that this cannot occur. A binding relationship anchors the chain gang to the specie stocks within the clearinghouse system. However, cointegration is a long-run relationship and one may object that *in the long run we are all dead!* There may indeed be a long-run relationship between inside money and reserves yet in-concert overexpansions are *short-run* episodes where note issues manage to "run away" from their golden anchor. To what extent such episodes are economically important depends on how quickly the clearinghouse corrects deviations from the long-run equilibrium relationship.

We begin informally by examining, at the state-level, how the ratios of note issues to specie stocks evolve over time relative to their series means. Since we are concerned primarily with the *in-concert* overexpansion hypothesis, we also report the correlations of these deviation series across New England states.

More formally, we explore the error-correction mechanism by first estimating an OLS fixed effects regression of (3.7) above. The residuals, $\hat{\varepsilon}_{it}$, are collected. If $y_{1,it}$ and $y_{2,it}$ are cointegrated then the residual series are stationary. The residuals are then included as regressors in an error correction model,

$$\Delta y_{1,it} = \gamma_{i0} + \alpha_1 \Delta y_{1,it-1} + \cdots + \alpha_p \Delta y_{1,it-p} + \beta_1 \Delta y_{2,it-1} + \cdots + \beta_p \Delta y_{2,it-p} + \rho \hat{\varepsilon}_{i,t-1} + u_{it} \tag{3.9}$$

The parameter, ρ, is of interest and represents the speed of correction to deviations from the long-run relationship. The model, (3.9) is estimated using OLS with fixed effects.

4. Results

We begin with an examination of state level (logs of) note issues and specie. Determining whether or not state-level note issues and specie stocks are governed by unit root processes is important for moving ahead to a cointegration analysis. If the series are stationary, the results from cointegration analysis will be, at best, difficult to interpret and, at worst, spurious. The individual ADF tests reported in Table 2 offer little evidence of stationarity. When the null is rejected (in particular for Rhode Island note issues) the significance level is marginal. Here we report results from the Levin et al. (2002), Im et al. (2003) and Maddala and Wu (1999) panel unit root tests in order to better utilize variation in data from the Suffolk System taken as a whole.

In addition to note issues and specie, we also report results for logged reserve ratios (specie divided by notes). Examining the stationarity of the reserve ratios is another (less formal) examine whether a linear combination of (log) note issues and specie stocks trend-reverting.

4.1. Results from panel unit root tests

Table 3 reports the results from the panel unit root tests described in Section 3.2.

All tests require specification of lag numbers (p) and we report results for each test assuming both $p = 2$ and $p = 4$ years.[15] All tests include constants. In all series depicted in Fig. 1 there is at least the suggestion of an upward trend or "drift". This would

[15] Invariably the Schwarz information criterion (SIC) is decreasing in the number of lags up through $p = 14$ or higher. With a total number of years of 34, and with three states having at most 25 yearly observations, such a lag structure is implausible.

Table 4
Panel cointegration tests on (logs of) note issues and specie stocks.

	Test statistics			
	State-level notes; state-level specie	(Weighted)	State-level notes; total specie	(Weighted)
Panel v-stat	0.491	−0.166	2.456***	1.684**
Panel ρ-stat	−2.056**	−2.004**	−3.048***	−2.613***
Panel t-stat	−3.857***	−4.118***	−3.917***	−3.637***
Panel ADF-stat				
2 lags	−1.555*	−1.789**	−0.399	−0.495
4 lags	−1.833**	−1.507*	−1.832**	−1.662**
Group ρ-stat	−0.769		−1.471*	
Group t-stat	−3.755***		−3.361***	
Group ADF-stat				
2 lags	−1.712**		−0.058	
4 lags	−1.950**		−1.300*	

Notes: all tests include trends and intercepts. Null hypothesis is no cointegration. "Weighted" refers to statistics weighted by member-specific long-run conditional variances.
* Rejection at the 10% significant level.
** Rejection at the 5% significant level.
*** Rejection at the 1% significant level.

be expected for expanding economies. The trends and/or drifts do not appear homogenous across states so all tests allow for state-specific time trends.

The baseline Levin et al. (2002) tests never reject the unit root null. Regardless of whether the variable being considered is notes or specie; and regardless of one or two lags being assumed, there is no evidence against assuming that the series are non-stationary. The unit root null is also not rejected for the reserve ratio.

Unlike Levin et al.'s test, the test of Im et al.'s (2003) allows us to permit the possibility of cross-section New England state-specific roots. Based on this test, unit roots for notes or specie are never rejected. For the reserve ratio, alternatively, the test based on a specification with two lags rejects the null at the 5% level. If we accept that notes and specie are both non-stationary series, then this rejection is consistent with the Selgin hypothesis: while both note issues and specie stocks are random (possibly drifting) walks, they are linked by a long-run (stationary) relationship; note issues will not "wander" too far from their base of reserves. Alternatively, using a four lag structure, Im et al.'s test does not reject the null for the reserve ratio.

Like Im et al. (2003), Maddala and Wu's (1999) test also allows for New England-state specific roots. The empirical results of the test are, in this case, also similar to those obtained with Im et al.'s test. Unit roots for notes or specie are never rejected. For the reserve ratio, the test based on a specification with two lags rejects the null, this time at the 10% level. The results of Maddala and Wu's test may be viewed as consistent with the Selgin hypothesis. More importantly, none of the panel unit root tests provide evidence that either note issues or specie stocks from the Suffolk System are stationary. This lack of evidence justifies our moving forward to a panel cointegration of those two series.

4.2. Results from panel cointegration tests

Table 4 reports the results of cointegration tests based on the Pedroni (1999, 2004) test statistics. (Of these, only the ADF-based test statistics require specification of lags; for those we report, again, for both $p = 2$ and $p = 4$.) For several of the test statistics, we also report "weighted" versions where, as suggested by Pedroni (2004), the weights incorporated into the test statistics are the cross-section unit-specific long-run conditional variances. The null hypothesis is always that the two series are not cointegrated.

We report results from cointegration tests of (i) state-level note issues and state-level specie stocks and (ii) state-level note issues and the aggregate (Suffolk-wide) specie stock. Results from the former set of tests, (i), we interpret as relevant to whether or not banks under the Suffolk System constituted a "chain gang". The results of the later set of tests, (ii), we interpret as speaking to whether or not the Suffolk effectively "policed" the chain gang, i.e., prevented them from over-expanding in-concert.

The first column of results in Table 4 reports the non-weighted test statistics for New England state-level note issues and specie stocks. At the 10% level or better, the no cointegration null is rejected based on seven out of nine reported test statistics. In all but one of these seven cases, rejection is at least at the 5% level. The second column of results in Table 4 reports weighted versions of five of those test statistics and in all but one case the null is rejected at the 10% level or better. While there is clearly heterogeneity across test results, the preponderance of evidence suggests a rejection of the no cointegration null hypothesis.

The remaining two columns of results in Table 4 are analogous to the first two, except that now the total (aggregate) Suffolk System specie stock replaces state-level stocks. The null hypothesis, then, is that New England state-level note issues do

Table 5
Correlations of state-level notes to specie ratio deviations from means.

	MA	VT	NH	CT	RI	ME
MA	1.000	0.491	−0.006	0.547	0.327	−0.046
VT		1.000	0.013	0.600	0.087	−0.042
NH			1.000	−0.095	0.699	−0.427
CT				1.000	0.115	0.267
RI					1.000	−0.391
ME						1.000

Notes: series are computed by taking the natural log of the notes to specie ratio then subtracting the sample mean of that logged ratio.

not have a long-run (cointegrating) relationship to the Suffolk's total reserve base. The third column of results in Table 4 contains the non-weighted test statistics. Once again, based on seven of the nine test statistics the non-cointegration null is rejected at the 10% level or better. In four of those nine cases, rejection is at better than the 1% significance level. Table 4 's fourth column of results contains five weighted test statistics. Four of those five indicate rejection of the null at the 5% level or better.

Conditional on note issues and specie stocks being non-stationary, the preponderance of evidence contained in Table 4 supports the Selgin (2001, 2010) hypothesis. Within the Suffolk System, adverse clearings checked given individual banks from expanding their note issues and precautionary reserve demands check in-concert overexpansions.

4.3. Results on error-correction mechanisms

If in-concert overexpansion was checked by the Suffolk, then how *quickly* was it checked? We begin by illustrating in Fig. 4 how notes to specie ratios evolved for each state during the Suffolk era. For all states except Massachusetts and Maine a time trend is statistically significant and positive. However, only for New Hampshire and Rhode Island can the trend be considered economically significant. The Massachusetts time trend is not statistically significant and Maine's is negative.[16] A visual inspection of the deviation series for Massachusetts, Vermont, Connecticut, and Maine (where the trends are not significant or economically small), "large" deviations from the mean appear to have been short-lived in most cases. Furthermore, Table 5 reports the correlations of the deviation series across New England states. The cross-correlations are typically low (i.e., less than 0.600) and never greater than 0.699. If economically important in-concert overexpansion occurred during the Suffolk era, we would expect these cross-correlations to be higher.

The analysis of the deviations in Fig. 4 is admittedly informal. Table 6 reports the more formal results of estimating error-correction models of state-level note issues, (3.9), using the residuals from the cointegrating relationship, (3.7). Changes in state-level note issues are related to their own lagged values and (a) lagged changes in state-level specie stocks or (b) lagged changes in the total specie stock in the Suffolk. We report results for both $p = 2$ and $p = 4$ lags.

Considering the regressions using state-level specie stocks, the error-correction parameter (ρ) estimate is only statistically significant when $p = 4$. In that case, the point estimate for ρ is −0.132. This implies that deviations from the long-run cointegrating relationship had a half-life of between 3 and 4 years. Of course, the statistically insignificant estimate from the two lag specification could indicate either an actual error correction parameter close to zero *or* a parameter estimated very imprecisely. The best we can do here is to note that the point estimate (−0.078) implies an error half-life of between 4 and 5 years Fig. 5.

Since the Suffolk's performance is being evaluated as a clearinghouse *system*, it is the adjustment to the system-wide reserves that may hold the most interest. When considering the relationship of note issues to the total, Suffolk-wide specie stock, the ρ estimate is statistically significant at the 10% level or better when either two or four lags are included. The smaller of the two (−0.184 when $p = 2$; significant at the 10% level) implies an error half-life of about two and a half year. The larger of the two (−0.327 when $p = 4$; significant at the 5% level) implies a half-life less than 2 years long.

We will conservatively use the longer implied half-life. Is two and a half years long or short? There is no objective standard to judge *fast* versus *slow* in this context. On the one hand, during the nineteenth century time period covered by the NBER (1854 through 1900) the average expansion is 27 months (2.25 years) and the average recession is about 23 months. Our conservative estimate of the error half-life is greater than either of these averages. One plausible interpretation, then, is that the Suffolk System provided a check on overexpansion, but not within a timeframe that would have been necessary to prevent business cycle-type disturbances to the economy. Alternatively, the estimates suggest that the Suffolk prevented from overexpansion from *continuing* for 2 years or more. Rather, within 2 years the Suffolk was able to reign in almost half of an overexpansion of notes. We tend to take this latter view and interpret evidence as suggesting that the Suffolk was effective at policing the chain gang. This is largely based on our prior belief that monetary overexpansion is destabilizing only when it is ongoing for a significant period of time.

[16] These remarks are based on regressing the natural log of the ratio of note issues to specie stocks on a constant and time trend. Only for New Hampshire and Rhode Island are the time trend coefficients greater than 0.020 (0.070 and 0.052 respectively). Maine's time trend is negative and significant (−0.016).

Table 6
Estimates of error-correction mechanism for state-level (logs of) note issues.

	Error-correction parameter (ρ)	
	State-level specie	Total specie
2 lags	−0.078 (0.048)	−0.184* (0.106)
R^2	0.121	0.244
Durbin–Watson	1.854	1.692
SIC	0.198	0.227
4 lags	−0.132** (0.055)	−0.327** (0.134)
R^2	0.166	0.335
Durbin–Watson	1.839	2.027
SIC	0.267	0.216

Notes: estimates come from fixed-effects estimation of (3.9). Standard errors are in parentheses.
*** Rejection at the 1% significance level.
* Rejection at the 10% significant level.
** Rejection at the 5% significant level.

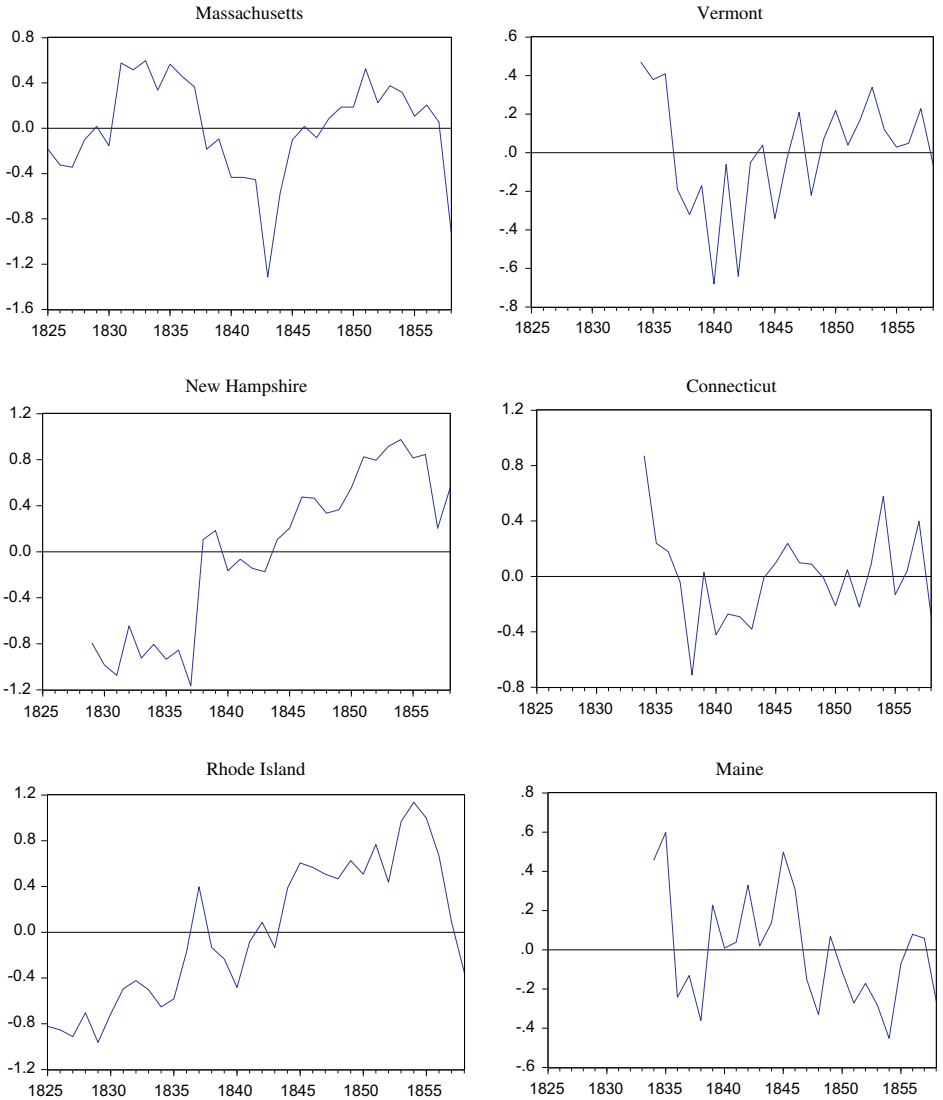

Fig. 5. State-level deviations from the mean notes to specie ratio. Series are computed by taking the natural log of the notes to specie ratio then subtracting the sample mean of that logged ratio.

5. Did the Suffolk prevent overexpansion? Some supporting evidence

We have interpreted our results as supporting the Selgin (2001, 2010) "chain gang" hypothesis. Is such an interpretation consistent with the historical record? We have already admitted above that they are open to subjective interpretation, especially in relation to the speed of error correction in the Suffolk. Furthermore, it is possible that the error correction was accounted for by some mechanism other than the Suffolk's clearings. In particular, it is possible that interregional Humean price-specie flows provided the relevant constraint on New England banks.

In this section we address these concerns in two ways. First, we provide some informal supporting evidence from the Suffolk's performance during the US banking panic of 1837.[17] This informal evidence, we believe, supports the view that the banks operating under the Suffolk performed well relative to other US banks. Second, while we do not have data on interregional specie flows, we discuss data available from Margo (2001) on regional price levels and inflation rates during the 1825–1858 period. There is little to suggest that conventional price-specie flows were the true mechanism checking overexpansion by New England banks.

In the immediate aftermath of the panic, the Suffolk (along with many banks nationwide) suspended specie payments. However, leading up to the panic, there had been questionable expansions in lending and decreases in banks' reserve ratios operating in the Suffolk System. For example, by April of 1836 there were 44 banks that had overdrawn their accounts at the Suffolk (Whitney, 1878, p. 25). Obviously this suggests that the Suffolk was not immune from national inflations and contagion from resulting crises. However, more telling is the performance of the Suffolk and New England banks *relative* to other banks in the US.

We know that in the 5 years following the 1837 panic 194 of the 729 then-chartered US banks failed, or just under 27% (Rousseau, 2002, p. 457). In New England following the crisis, between 11 (White, 1989, p. 330) and 32 (Knox, 1900, p. 362) Massachusetts banks failed. Not a single Connecticut bank failed (Trivoli, 1979, p. 22; Knox, 1900, p. 380) and only one Rhode Island bank failed (Knox, 1900, p. 372). For New Hampshire we know that the total number of banks in that state fell from 28 in 1837 to 17 in 1845 (Knox, 1900, 340). Much of this decrease was presumably due to the panic. Although the number of bank failures that occurred as a direct result of the panic in Maine and Vermont is unknown, the Annual Report of the Comptroller of the Currency (1876) showed that in 1837 there were 53 banks in Maine and 19 banks in Vermont. In 1842, 5 years after the panic, there were 40 banks in Maine and 17 banks in Vermont. As far as the total number of banks in the Suffolk as of 1837, 300 seems to be a reasonable estimate (Rolnick et al., 1998, p. 14; Trivoli, 1979, p. 14). If we take 59 banks out of 300, that is less than 20% of Suffolk banks that failed.[18] By this measure the Suffolk fared well relative to the nation as a whole.

Also, in a comparison of Massachusetts banks to Pennsylvania banks (which had no Suffolk-like clearinghouse), Smith and Weber (1999, p. 656) report that in the years following the panic, net note creation as a ratio of percent of balance sheets fell dramatically from above 0.25 to about 0.10 in 1840; "[n]et note issue by Massachusetts banks, in contrast, remained roughly constant during this period." A reasonable interpretation is that the Suffolk allowed Massachusetts banks to keep lending while banks lacking such a clearinghouse system found themselves in a marked contraction of credit.

We can also report some anecdotal evidence on the performance of the Suffolk during and following the 1837 panic. On May 12th of 1837 the Suffolk (along with banks in New York, Philadelphia, and elsewhere) suspended payment in specie but by May 29th the president of the Suffolk wrote: "In regard to resuming specie payments, I can only say that we are ready to commence again today, and intend to remain in this condition till [*sic*] others so are ready" (Whitney, 1878, p. 28). By April of 1838, "[c]onfidence was restored – so much so that during the first week of resumption [of specie payments] no bank in Boston was called upon for over $500 in specie on any one day, and in many banks more specie was deposited than was paid out" (Whitney, 1878, p. 30). Former US comptroller of the currency, John Jay Knox (1900, p. 382), concluded in his *A History of Banking in the United States* that the "Suffolk Bank system of redemption imposed a salutary check upon excessive circulation and made it impossible for the banks to sustain as large note issues as they were legally entitled to[;] was far more effectual and rational than any law could have effected."

Finally, Margo (2001) reports regional price deflators for the US during the years of the Suffolk. Unfortunately the regions are US Census regions, so the *Northeast* contains New York, Pennsylvania, and New Jersey, as well as the New England States. However, we can look at the annual relationship between the price level and inflation rate in the Northeast and the *Midwest, South Atlantic*, and *South Central* regions. The correlations between the Northeast price level and other regions are all above 0.917; between the Northeast annual inflation rate and other regions all above 0.868. In particular, inflation rates in all regions spiked in 1836 preceding the panic and then turned to deflation in 1837. More generally, if we observed episodes where prices in the Northeast rose significantly relative to those in other regions then we might suspect that specie outflows

[17] The other major panic that occurred during the Suffolk's existence was that of 1857. However, as noted the Bank of Mutual Redemption was chartered in 1855 and by 1857 the Suffolk was being pressured by bank commissioners to withdraw from a dominant position in the market. The panic hit in September of 1857; by October of 1858 the Suffolk had issued a circular stating that "[t]he time has arrived to surrender our agency in the system as heretofore conducted" (Lake, 1947, p. 201). In none of the accounts that we read was the panic mentioned as an important determinant of the Suffolk's decision.

[18] Here we are counting all of the decrease in NH, ME and VT banks as failures and assuming the higher number (32) of Massachusetts bank failures. Thus, even this maximum bound would suggest that the percentage of bank failures in New England was still below the national average.

from the Northeast were checking overexpansions (rather than, in New England, the Suffolk clearinghouse). However, there is no *prima facie* evidence of such episodes. Notably, in 1836 the Northeast inflation rate was the *lowest* of the four regions.[19]

6. Concluding discussion

A longstanding debate considers the stability of a monetary system under a private note clearing regime. While adverse clearings will check individual banks from over-expanding note issues, numerous authors argue that in-concert overexpansion would not be checked.

Selgin (2001, 2010) argues that during an incipient in-concert overexpansion, precautionary reserve demands will increase, causing banks to curb their note issues. An increase in precautionary demands occurs because the variance of net clearings increases. To use Selgin's (2010) analogy, banks operating within this type of note clearing regime represent a chain gang where an overexpansion can occur only if all banks move forward together. However, the clearinghouse system effectively polices the chain gang.

Until now this theoretical debate has relied on historical narratives to support either claim. We complement the narratives by proposing an econometric evaluation of the in-concert overexpansion hypothesis using cointegration tests and the estimation of error correction models. We study a panel of state level data from the Suffolk Banking System which operated in New England between 1825 and 1858. These data are a rich source of evidence on the workings of an actual private clearinghouse banking system; the Suffolk System also closely approximated the assumptions of Selgin's theory: (1) rapid note redemption, (2) penalization of member banks for holding negative balances with one another and (3) a penalty rate charged on interbank lending.

Several tests reject the no-cointegration null hypothesis for (i) state-level note issues and state-level specie stocks and (ii) state-level note issues and the aggregate (i.e., Suffolk System-wide) specie stock. We interpret (i) as supportive of the view that banks under the Suffolk-System represented a chain gang in the sense that the principle of adverse clearings prevented individual banks from expanding their note issue in increasing proportion to both their reserves and the note issues of other banks. Additionally, (ii) suggests that the chain gang was effectively policed by the Suffolk System. In addition to banks' note issues being cointegrated, the aggregate of reserves in the system provided an anchor to aggregate note issues.

Furthermore, error-correction models suggest that deviations from the long-run equilibrium of note issues and Suffolk-wide reserves were, all else equal, halfway corrected in about 2 years. The fact that the error-correcting relationship is stronger for Suffolk-wide specie than for state-level reserves suggests that the Suffolk was most effective as a clearinghouse *system* preventing *in-concert* overexpansion from occurring.

Our analysis is not definitive. Further study at the level of individual banks is desirable. Also, there is no objective standard for what constitutes, in this context, *fast* versus *slow* error correction. Other researchers, taking our results for granted, may come to very different views on the effectiveness of the Suffolk System. However, we believe that we have provided an interesting approach that can be applied to available data from other historical episodes. Furthermore, we believe that we have provided a baseline for further examination of the Suffolk.

References

Banker's Magazine and Statistical Register, Various Years.
Bodenhorn, H., 2002. Making the little guy pay: payments-system networks, cross subsidization, and the collapse of the Suffolk System. The Journal of Economic History 62, 147–169.
Bordo, M.D., Schwartz, A.J., 1996. The performance and stability of banking systems under 'self-regulation': theory and evidence. Cato Journal 14, 453–479.
Calomiris, C.W., Kahn, C.M., 1996. The efficiency of self-regulated payments systems: learning from the Suffolk System. Journal of Money, Credit and Banking 28, 766–797.
Dowd, K., 1993. Laissez-Faire Banking. Routledge, London.
Dowd, K., 1994. Competitive banking, bankers' clubs, and bank regulation. Journal of Money, Credit and Banking 26, 289–308.
Engel, R.F., Granger, C.W.J., 1987. Co-integration and error-correction: representation estimation, and testing. Econometrica 55, 251–276.
Fisher, R.A., 1932. Statistical Methods for Research Workers. Oliver & Boyd, Edinburgh.
Glasner, D., 1989. Free Banking and Monetary Reform. Cambridge University Press, Cambridge.
Goodhart, C.A.E., 1988. The Evolution of Central Banks. MIT Press, Cambridge, MA.
Gorton, G., 1985. Clearinghouses and the origin of central banking in the United States. The Journal of Economic History 45, 277–283.
Gorton, G., Mullineaux, D.J., 1987. The joint production of confidence: endogenous regulation and nineteenth century commercial-bank clearinghouses. Journal of Money, Credit and Banking 19, 457–468.
Hayek, F.A., 1978. The Denationalisation of Money: The Argument Refined, second ed. extended. Institute of Economic Affairs, London.
Hunt's Merchants Magazine and Statistical Review, Various Years.
Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. Journal of Econometrics 115, 53–74.
Knox, J.J., 1900. A History of Banking in the United States. Bradford Rhodes & Co., New York.
Lake, W.S., 1947. The end of the Suffolk System. Journal of Economic History 7, 183–207.
Laidler, D., 1992. Free banking theory. in (Eatwell et al., eds.) The New Palgrave: A Dictionary of Money and Finance. Macmillan, New York, NY.
Levin, A., Lin, C.F., Chu, C.S., 2002. Unit root tests in panel data: asymptotic and finite-sample properties. Journal of Econometrics 108, 1–24.
Maddala, G.S., Wu, S., 1999. A comparative study of unit root tests with panel data and a new simple test. Oxford Bulletin of Economics and Statistics 61, 631–652.

[19] The possibility remains that sub-regional price-specie flows within the Northeast were the effective check on New England bank overexpansions. However, if six out the nine Northeastern states experienced an episode of relatively high inflation, it would likely be evident in a relatively high inflation rate for the entire Northeastern region.

Margo, R.A., 2001. Wages and prices during the antebellum period: a survey and new evidence. In: Gallman, Wallis (Eds.), American Growth and Standards of Living before the Civil War. University of Chicago Press, Chicago.
Mullineaux, D.J., 1987. Competitive monies and the Suffolk bank system: a contractual perspective. Southern Economic Journal 53, 884–898.
Pedroni, P., 1999. Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxford Bulletin of Economics and Statistics 61, 653–670.
Pedroni, P., 2004. Panel cointegration: asymptotic and finite sample properties of pooled time Series tests with an application to the PPP hypothesis. Econometric Theory 20, 597–625.
Rolnick, A.J., Smith, B.D., Weber, W.E., 1998. Lessons from a laissez-faire payments system: the Suffolk Banking System (1825–1858). St. Louis Federal Reserve Bank's Review 80, 105–116.
Rousseau, P.L., 2002. Jacksonian monetary policy, specie flows, and the panic of 1837. Journal of Economic History 62, 457–488.
Selgin, G., 1988. The Theory of Free Banking: Money Supply Under Competitive Note Issue. Rowman and Littlefield, Totowas, NJ.
Selgin, G., 1994. Free banking and monetary control. Economic Journal 104, 1449–1459.
Selgin, G., 2001. In-concert overexpansion and the precautionary demand for bank reserves. Journal of Money, Credit and Banking 33, 294–300.
Selgin, G., 2010. Central banks as sources of financial instability. Independent Review 14, 485–496.
Selgin, G., White, L.H., 1994. How would the invisible hand handle money? Journal of Economic Literature 32, 1718–1749.
Smith, B.D., Weber, W.E., 1999. Private money creation and the Suffolk Banking System. Journal of Money, Credit and Banking 31, 624–659.
Trivoli, G., 1979. The Suffolk Bank: A Study of a Free-Enterprise Clearing System. Adam Smith Institute, London.
U.S. Comptroller of the Currency, 1876. Annual Report of the Comptroller of the Currency.
Weber, W.E., 2008. Balance Sheets for U.S. Antebellum State Banks. Research Department, Federal Reserve Bank of Minneapolis.
White, L.H., 1989. Competition and Currency. New York University Press, New York.
Whitney, D.R., 1878. The Suffolk Bank. The Riverside Press, Cambridge.