JOURNAL OF ECONOMICS AND FINANCE • Volume 25 • Number 2 • Summer 2001

Excess Reserves during the 1930s: Empirical Estimates of the Costs of Converting Unintended Cash Inventory into Income-Producing Assets

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Abstract

It is often argued that the persistent amounts of excess reserves in the 1934-1941 period were sought either for protective liquidity or as a signal of bank safety to depositors. More recent explanations argue that these excess reserves were unintended inventory due to the high internal adjustment costs of converting reserves to income-producing assets. Our findings support the latter explanation and reveal high internal asset adjustment costs after 1933. Thus, a monetary policy focused on increasing reserves would have been ineffective. A successful monetary policy would be one that increased outside money. (*JEL G210, G280, O420*)

Introduction

The modern theory of the banking firm posits that an increase in the demand for loans and securities (bank outputs) leads to an increase in the bank's demand for deposits (inputs).[1] In this context, the acquisition of deposits is endogenous to bank managerial decisions. A departure from deposit endogeneity occurred during the decade of the 1930s. There were at least two contributing factors. First, banking legislation of the time reduced the ability of banks to price-compete for deposits by instituting Regulation Q and by placing a ban on paying interest on checking deposit accounts.[2] Second, as shown in Table 1, there was a rapid return of deposits following the Bank Holiday (declared on March 6, 1933) but to a smaller number of banks. Between 1929 and 1933, the number of banks declined from 24,633 to 15,015.[3]

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[1] This view can be traced back to Sealey and Lindley (1977).

[2] The legislation was contained in two acts: the Banking Act of 1933, which created deposit insurance, and the Banking Act of 1935.

[3] Bank numbers are taken from the Board of Governors of the Federal Reserve, 1943, *Banking and Monetary Statistics*, Washington, D.C., p. 16.

TABLE 1. PERCENTAGE CHANGE IN DEPOSITS

Year	Deposit Growth %
1934	11.8
1935	10.2
1936	13.2
1937	2.3
1938	-.7
1939	9.2
1940	10.2
1941	10.4

Note: Deposit growth rates are measured from June to June. Data for growth rates are taken from Board of Governors of the Federal Reserve, *Banking and Monetary Statistics*, pp. 17.

As a result of the legislation and the unprecedented inflow of deposits, bankers had little ability or incentive to manage liabilities and, instead, focused on managing assets. In a sense, bankers of the 1930s more closely resembled portfolio managers rather than conventional bankers.[4]

A feature of this environment was the emergence of an unprecedented level of excess reserves in the banking system after the 1933 Bank Holiday.[5] Explanations for the accumulation of excess reserves can be separated into two categories. One category represents explanations based on the premise that excess reserves were desirable or sought. Here one finds the seminal work of Friedman and Schwartz (1963), Morrison (1966), Frost (1971), and the more recent contributions of Calomiris and Wilson (1996) and Ramos (1996). Consistent themes in this category are that (1) bankers were motivated to seek out excess reserves due to a desire for protective liquidity, (2) excess reserves were a signal to depositors that the bank was safe, and (3) interest rates were low compared to brokerage fees on securities making their acquisition unprofitable. Underlying these themes is an assumption that the accumulation of excess reserves was desired and sought because of the absence of alternative forms of protection from uncertainty.[6] In addition, there is an implied assumption that banks were actively managing liabilities in the traditional manner of the banking firm.

A second category reflects the view that the excess reserve accumulation was undesired and caused by exogenous economic factors. Bernanke (1983, 1995), Bernanke and Gertler (1990), and Ferderer and Zalewski (1994) argue that credit intermediation became less efficient and more expensive as lenders had difficulty discriminating between "good borrowers" and "bad borrowers." Mason, Anari, and Kolari (2000) point out the economic drag of the slow liquidation of failed bank assets (deposits in failed banks) during this period. From a microeconomic perspective, Mounts, Sowell, and Saxena (2000) argue that the excess reserves were not only undesired, but were actually an unintended inventory of cash. After controlling for external factors, including uncertainty in deposit and loan behavior, and for the interest rate concerns of Frost, they find that banks faced significant internal (scale-related) costs in moving from actual

[4] Bankers were confronting a situation similar to that of a mutual fund that experiences large cash inflows when its investment opportunities are restricted to a narrow range of assets.

[5] Excess reserves are reserves above required reserves. Warburton notes, "This episode is the only exception to the general tendency of Federal Reserve member banks to expand in line with changes in their reserve position" (Warburton, 1950, p. 540).

[6] Alternative forms of protection would be a willing lender of last resort as suggested by Friedman and Schwartz (1963) and access to *de novo* capital as suggested by Calomiris and Wilson (1996) and Ramos (1996).

cash holdings to desired or targeted cash holdings. Inherent in this literature is an assumption that liabilities were not being managed in the traditional manner because the traditional substitution of reserve cash for income earning assets was not occurring.

Not only do these competing explanations for the accumulation of excess reserves present polar-opposite descriptions of bank behavior, they also have polar-opposite implications for monetary policy. If excess reserves were desired, then a monetary expansion that increased bank reserves would increase the money supply through the banking channel once the desire for reserves was satiated. This, of course, is the standard process through which monetary policy is viewed today. However, if excess reserves were undesired (unintended inventory), then a monetary policy focused on increasing reserves would have little effect on the money supply, as there would be few additional loans. To increase the money supply in this case, the monetary base (outside money) would have to increase significantly more since there would be a very small money multiplier.[7]

In this paper, we expand the issue of intended versus unintended excess reserve inventories by testing more formally for the presence of high internal-asset-adjustment costs. Mounts, Sowell, and Saxena (2000) demonstrated empirically that the excess reserves represented unintended inventory because of significant internal costs. While an important finding, it does not answer the question of how large these internal costs were in relative terms. While Mounts et al. used a simple lag structure to test for these costs, we employ a model utilizing dynamic optimization of a buffer stock of excess reserves that incorporates forward-looking expectations using bank and macroeconomic data from 1929 to 1941.

Estimating the magnitude of these costs would be important in evaluating how responsive banks would have been to an increased amount of bank reserves. If the magnitude of the internal costs in relative terms was small, then a steady increase in reserves would have been expected to lead to bank expansion, albeit slower expansion than if the costs had been low or zero. Conversely, if the relative internal adjustment costs had been high, then a steady increase in reserves would not have led to bank expansion (an increase in loans) and, as a policy, would have been ineffective in bringing about an economic recovery. High internal adjustment costs support the contention that recovery from the Depression would have required a monetary expansion composed of outside money (money not produced through private debt), while an expansion of reserves to stimulate bank lending would not have been successful. Thus, determining the relative size of the internal adjustment costs is important in determining whether the monetary policy of increasing reserves was not pursued with sufficient vigor, or whether even a vigorous pursuit of expanding reserves would have been ineffective because the economic conditions necessary for its success were missing.[8]

The next section presents the theoretical model. The third section describes the data used and the hypotheses to be tested. The following section reports the results of the empirical analysis. The conclusion and summary also offer a discussion of the nature of effective monetary policy given the findings reported in the fourth section. Overall, the results support the findings of Mounts, Sowell, and Saxena (2000) that the accumulation of excess reserves was unintended in large part

[7] Indeed, most of the expansion from 1934 through 1941 has been attributed to a large increase in outside money, mostly gold inflows (Romer 1992).

[8] It should be noted that critics of the Federal Reserve's actions during this period, such as Friedman and Schwartz as well as Warburton, were critical of the Fed's feeble and often counterproductive attempts to conduct monetary policy of any kind. The Fed did not conduct policy that expanded either bank reserves or fiat money. (Friedman and Schwartz 1963, p. 511). Romer notes, "While they were clearly aware that other developments led to a rise in the money supply during the mid-1930s, Friedman and Schwartz appear to have been more interested in the role that Federal Reserve inaction played in causing and prolonging the Great Depression than they were in quantifying the importance of monetary expansion in generating recovery" (Romer 1992, p. 758).

due to the high internal adjustment costs. In addition, the adjustment costs of deviating from target reserve levels were approximately 20 times greater for 1934-1941 than for 1929-1933. This clearly suggests that a given monetary policy (for example, an open market purchase) would have been more effective prior to the bank holiday than after.

The Theoretical Model

Our intent is to estimate the costs of adjusting asset portfolios before and after 1933. To do this, we employ a dynamic optimization format. In such a model, banks are assumed to have a target level of excess reserves that reflects a long run equilibrium relation of the form:

$$XR^*_t = \alpha_0 + \alpha_1 R_t + \alpha_2 D_t + \alpha_3 MP_t \tag{1}$$

where XR_t^* is the desired or target level of excess reserves, R_t is the yield on government securities, D_t represents the level of demand deposits, and MP_t is an indicator of monetary policy. R_t, D_t, and MP_t are forcing variables that reflect external or exogenous factors that condition the excess reserve target.[9] A variable for monetary policy (either the monetary base or the money supply) is included in the model because of the obvious relationship between money growth and bank credit.

Given a target level of excess reserves conditioned on the set of exogenous variables (R_t, D_t, MP_t), banks are assumed to minimize the expected discounted value of a quadratic loss function conditioned on their current period information set, which formulates short-run excess reserve decisions with the following objective function:

$$C = \min \left[E_t \sum_{t=0}^{\infty} \beta^t \left[w_0 \left(XR_t - XR_t^*\right)^2 + w_1 (XR_t - XR_{t-1})^2 \right] \right] \mid \Omega_t \tag{2}$$

where the following are defined at time t:

XR_t = actual excess reserve holdings

XR_t^* = desired excess reserve holdings

β = banks' subjective discount factor, $0 < \beta < 1$

w_0, w_1 = weighting factors

Ω_t = banks' information set

In this setup, banks face costs of adjustment in changing actual excess reserves to their desired levels, which they attempt to minimize over the course of the planning horizon. These costs are an overall indication of the ability, or rather inability, of banks to modify their asset portfolios.

Two sources of costs identified in (2). First, the term $(XR_t - XR_t^*)^2$ assigns a penalty to deviations from the current target level of excess reserves. Two items can be identified in this context. The first is the opportunity cost of holding more than the target level of excess reserves assumed to be the return associated with government securities. The second is the opportunity cost of holding less than the target level of reserves. These are the costs associated with banks' inability to meet unexpected deposit outflows.

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[9] It could be argued that the inclusion of R_t, and D_t may be referring to those variables subsumed under an interest rate model (Frost 1971) and a protective liquidity model (Friedman and Schwartz 1963) of the accumulation.

The second term in (2), $(XR_t - XR_{t-1})^2$, imposes convexity on the cost of changing the level of excess reserves. These costs can be thought of as the asset adjustment costs internal to the bank (conditioned on the external or forcing variables) inherent in converting excess reserve into other interest earning assets or vice versa. Since these costs have been conditioned on the external forcing variables, they represent the internal managerial costs of moving actual excess reserve holdings to desired or target levels.

The weights, w_0 and w_1, in (2) reflect the importance of each of the two sources of cost. In ratio form they may be viewed as an index of the importance of deviations from desired holdings relative to adjustments of excess reserves. If, in fact, banks faced increased costs in adjusting their asset portfolios after the bank holiday, then estimates of these weights should show differences before and during the accumulation. This is the principal focus of the paper.

Actual excess reserve holdings are assumed to have a planned and unplanned component so that the observed XR_t is

$$XR_t = XR_t^p + XR_t^u \tag{3}$$

where XR_t^p is the choice variable given by expression (2). The unplanned component, XR_t^u occurs due to surprises or innovations in interest rates, demand deposits, or monetary policy occurring between t-1 and t. In effect, these shocks are due to innovations that are beyond the control of the individual bank and reflect the impact of those factors in the first category of explanations for the reserve accumulation. These "surprises" are assumed to occur after the bank chooses a sequence of XR_t that solves expression (2). As a result, the innovations result in the accumulation of excess reserves over and above the buffer stock that would occur due to adjustment costs in expression (2).[10]

Minimization of (2) yields a set of Euler equations, which along with a transversality condition yields a forward convolution equation of the form:

$$XR_t^p = \lambda_1 XR_{t-1} \left(1-\lambda_1\right)\left(1-\lambda_1\beta\right) \sum_{j=0}^{\infty} \left(\lambda_1\beta\right)^j \left(E_{t-1}\, XR_{t+1}^*\right) \tag{4}$$

for t = (1, . . ., T) and where λ_1 is the stable root contained in the (0,1) interval.

Substitution of (1) for the target level of excess reserves into (4) yields:

$$XR_t = \lambda_1 XR_{t-1} + (1-\lambda_1)(1-\lambda_1\beta)\sum_{j=0}^{\infty}(\lambda_1\beta)^j E_{t-1}(\alpha_0 + \alpha_1 R_t + \alpha_2 D_t + \alpha_3 MP_t) + XR_t^u \tag{5}$$

Now, specialize XR_t^u to represent surprises originating in the restricted information set consisting of the forcing variables so that:

$$XR_t^u = \gamma_1\left(R_t - E_t R_t\right) + \gamma_2\left(D_t - E_t D_t\right) + \gamma_3\left(MP_t - E_t MP_t\right)$$

The model that results is the equation:

$$XR_t = \lambda_1 XR_{t-1} + (1-\lambda_1)(1-\lambda_1\beta)\sum_{j=0}^{\infty}(\lambda_1\beta)^j E_{t-1}(\alpha_0 + \alpha_1 R_t + \alpha_2 D_t + \alpha_3 MP_t)$$
$$+\gamma_1(R_t - E_t R_t) + \gamma_2(D_t - E_t D_t) + \gamma_3(MP_t - E_t MP_t) + \varepsilon_\varepsilon \tag{6}$$

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[10] The solution to expression (2) is given in Sargent (1987) and Hansen and Sargent (1981). Elsewhere, content-specific treatments appear in Cuthbertson and Taylor (1987) and Cuthbertson (1988).

which is estimated along with the set of forecasting equations for the forcing variables,

$$\theta(L)Z_t = \upsilon_t \tag{7}$$

where $Z = [R_t, D_t, MP_t]$, $\theta(L)$ is a 3x3 matrix of lag polynomials, and υ_t is a 3x1 vector of random error terms whose elements are assumed to be uncorrelated with the error term $\hat{a}$ in the expression (6).

Data on excess reserves (XR_t) and the yield on government securities (R_t) were taken from *Banking and Monetary Statistics* (1943). XR_t is the log of excess reserves, Table 101, pp. 369-372. R_t is the yield on government securities, Table 128, pp. 469-471. Data on deposits and the two monetary policy variables are given in Friedman and Schwartz (1963).

Data and Expectations

The model in (6) is estimated using monthly data for the period 1929-1941. The data for excess reserves (XR_t) and the yield on government securities (R_t) are taken from *Banking and Monetary Statistics* (1943). The data for deposits (D_t) and the monetary policy variable (MP_t) are taken from Friedman and Schwartz (1963). All data are seasonally adjusted.[11] XR_t and D_t are in logarithms.

The monetary policy variable (MP_t) is based on the first difference of the logarithm of the monetary base and M1, respectively. The yield on government securities R_t is expressed as a percentage.[12] All of the data are in nominal terms.[13]

The three variables R_t, D_t, and MP_t, along with their "surprise" counterparts (e.g., $S_tR_t = R_t - E_tR_t$, etc.) constitute the empirical model. Both MP_t and D_t can be regarded as shift variables of a static, or long-run, demand curve for excess reserves that is a function of R_t. The latter variable is viewed as predetermined in the present context in that R_t in expression (1) is determined by external aggregate credit or money markets. Since R_t represents the opportunity cost of holding excess reserves, an inverse relationship should characterize the XR_t^*, R_t relationship.

The shift variable MP_t should have a positive relation to excess reserves, both on the basis of previous empirical work and *a priori* arguments supporting the static model. The sign of the MP_t variable is expected to be positive in that changes in the monetary base end up as corresponding changes in reserves. In addition, insofar as this variable is a reflection of discount rate policy, it is expected to act as a positive shift variable. Including MP_t also allows for the isolation of the banks' excess reserve choices in response to shifts in deposits.

[11] Data on excess reserves (XR_t) and the yield on government securities (R_t) were taken from *Banking and Monetary Statistics* (1943). XR_t is the log of excess reserves, Table 101, pp. 369-72. R_t is the yield on government securities, Tables 128, pp. 469-71. Data on deposits and the two monetary policy variables are given in Friedman and Schwartz (1963).

[12] The interest rate used in the estimation is consistent with those used by Frost. However, the results reported below are insensitive to the interest rate that is selected.

[13] Estimation was carried out using real variables for XR_t, D_t, and R_t with no appreciable effect on the results. This is not surprising given the variables involved. Excess reserves and deposits are both in dollar terms where excess reserves are an amount over the percentage of deposits banks were required to hold. Deflation of deposits and excess reserves would be a scale shift in their values.

Equations (6) and (7) contain a set of nonlinear cross-equation restrictions on both the forward and backward parts of the model. The addition of the surprise terms further complicates joint estimation of (6) and (7).[14] To keep the process computationally tractable, the two-step approach is adopted. The nonlinear restrictions embedded in the system (6) and (7) are still imposed implicitly in the two-step procedure.[15]

Results

In this section we first discuss the results of estimating the entire model and how the results fit into the two categories of literature discussed above. Next, we use the general model to estimate the size of the costs associated with adjusting asset portfolios.

The Role of Deposits and Interest Rates in the Accumulation

The results in Table 2 provide data-acceptable forecasts of the forcing variables necessary for the first step of the two-step method of estimation used. Using the chain rule of forecasting, these equations provide the 1 through j step-ahead forecasts needed to represent the expectations and surprise components of expression (6). To implement successfully the estimation of expression (6), we limit the forward horizon leads. Initially, the series was limited to j = 12 leads, but then reduced to six since there appeared to be no essential difference in the estimates other than that induced by co-linearity in the expectation terms.

The results for the six leads case are reported in Table 3 for the two monetary policy variables (Base and M1). The discount factor, β =.997, is equal to an annual rate of approximately 3.6 percent, the average of R_t over 1929-1941.

As in Table 2, η_1 is the Lagrange Multiplier statistic for residual autocorrelation. η_6 is the ARCH test statistic based on Engle (1982). Since there appears to be evidence of an ARCH effect, (Table 3) t-ratios are computed using White's (1980) method of computing the covariance matrix.

Both the monetary base and M1 variants of the constrained model are statistically well determined. A test of the over-identifying restrictions is carried out using a simple likelihood ratio test, reported as η_7 in Table 3. The restrictions of the model are imposed on an autoregressive distributed lag (ADL) model. The constrained model imposes 20 - 8 = 12 restrictions on an ADL equation consisting of six lags for each of the forcing variables, a constant and one lag on excess reserves. The test statistic is distributed as χ^2 (12), and the marginal significance levels given in parentheses indicate that the model is consonant with the data.

As seen in Table 3, the coefficient (α_1) of the expected interest rate variable (R_t) is negative and significant. This validates the obvious presence of an opportunity cost of holding excess reserves. The long-run interest rate semi-elasticity of -2.48 (base equation) and -2.83 (M1 equation) seems reasonable for the sample period.[16] The coefficient (γ_1) of the corresponding surprise variable (SR_t) is negative and significant as well. As expected yields rise, the inverse relation to excess reserves is exacerbated by shocks. This suggests that planning by banks concerning excess reserves relative to interest rates and interest rate shocks is consistent with expected normal bank practice, contrary to Frost's interest rate based model for the accumulation.

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[14] Successful joint estimation of (6) and (7) becomes unduly complex when dealing with monthly data if (7) has long lags and a VAR representation. The addition of surprise terms, so crucial to an explanation of the 1930s, imposes a formidable programming and computational burden. The problem is simplified by restricting (7) to have a univariate representation in each of the forcing variables.

[15] See Cuthbertson and Taylor (1989) for a derivation of the restrictions.

[16] The results are insensitive to the interest rate selected.

TABLE 2. STEP ONE FORECASTS MAY 1929 TO DECEMBER 1941 - T=152 MONTHS

For Lag Number	ΔR_t	ΔD	MP_t $\Delta^2 B_t$	MP_t $\Delta^2 M_t$
-1	.2255	-.0795	-.9060	-1.1640
	(2.77)	(0.98)	(10.98)	(14.25)
- 2	-.0734	.1653	-.8887	-.9700
	(2.77)	(2.04)	(7.88)	(7.98)
- 3	-.0551	.1569	-.7305	-.6601
	(0.66)	(1.92)	(5.39)	(4.80)
- 4	-.0797	.0561	-.6813	-.5727
	(0.96)	(0.68)	(4.58)	(4.16)
- 5	-.0590	.1043	-.6096	-.4211
	(0.71)	(1.29)	(3.87)	(3.47)
- 6	-.1926	.2081	-.5183	-.1586
	(2.39)	(2.56)	(3.20)	(1.39)
- 7			-.4059	
			(2.51)	
- 8			-.3046	
			(1.93)	
- 9			-.0903	
			(0.60)	
- 10			-.0426	
			(0.31)	
- 11			-.0533	
			(0.47)	
- 12			-.2061	
			(2.47)	
$\hat{\sigma}$	.0937	.0233	.0178	.0165
η_1	2.79	1.88	12.94	3.71
	(0.85)	(0.94)	(0.46)	(0.74)
η_2	.97	.29	.38	.32
	(0.99)	(0.99)	(0.99)	(0.99)
η_3	.93	.28	.68	.32
	(0.56)	(0.99)	(0.99)	(0.99)
η_4	-1.29	.78	-1.64	-.63
η_5	-5.74	-3.14	-5.15	-8.96

Notes: t-values are reported in parentheses below the corresponding estimates. MP_t = Monetary policy: $\Delta^2 B_t$ = Change in monetary base: $\Delta^2 M$ = Change in M1: $\hat{\sigma}$ = standard error of estimate: η_1 = portmanteau Lagrange multiplier test for r-th order residual autocorrelation, distributed as $X^2(r)$ under the null.: η_2 = forecast $X^2(24)/24$ on null of parameter constancy between estimation (1929:7-1939:12) and forecast (1940:1-1941:12) period.: η_3 = Chow test of constancy between estimation and forecast period.: η_4 = t-test for zero forecast innovation mean. η_5 = unit root t-test.

TABLE 3. SIX LEADS CASE JULY 1929 TO DECEMBER 1941 (T=152 MONTHS)

Variable	Monetary Policy	
	Base	M1
Constant (α_0)	40.7512	56.7599
	(27.06)	(22.46)
R_t (α_1)	-2.4858	-2.8335
	(4.11)	(3.42)
D_t (α_2)	-2.7903	-4.2380
	(3.04)	(2.59)
MP_t (α_3)	66.9616	44.5959
	(3.74)	(1.62)
SR_t (γ_1)	-.5998	-.4887
	(2.58)	(2.08)
SD_t (γ_2)	.5882	-.4439
	(0.63)	(0.29)
SMP_t (γ_3)	3.1862	1.9008
	(3.54)	(1.04)
Stable Root ($\lambda 1$)	.8839	.9238
	(27.06)	(22.46)
$\hat{\sigma}$	.1885	.1952
η_1	2.62	1.99
	(0.85)	(0.92)
$\eta_6(1)$	5.17	6.90
	(0.23)	(0.01)
$\eta_7(12)$	12.56	2.48
	(0.55)	(0.99)
$\phi(36)$	25.93	31.69
	(0.89)	(0.67)

Notes: t-values are reported in parentheses below the corresponding estimates. $\hat{\sigma}$= standard error of estimate: η_1 = portmanteau Lagrange multiplier test for r-th order residual autocorrelation, distributed as $X^2(r)$ under the null.: η_6 = ARCH test.: η_6 = Likelihood ratio test: ϕ = Box-Pierce test.

The coefficient (α_2) for the expectations deposit variable (D_t) is negative and significant. This result is not consistent with the hypothesis that banks were pursuing protective liquidity. If banks had been pursuing protective liquidity, a fear of deposit outflows would dominate the decisions of bankers. However, that domination of decision-making would be reflected also in the "surprise variable" (SD_t). The pursuit of protective liquidity would suggest that the coefficient (γ_2) for the "surprise variable" (SD_t) should be positive and significant. Banks would be responding to "surprise" deposits by increasing excess reserves. This is not the case. The variable (SD_t) has coefficients that are insignificant in both versions of the excess reserve equation. Unexpected deposit behavior, insofar as it is captured in the D_t variable, does not condition the excess reserve target. Deposits were an important influence on excess reserve levels, but contrary to the portrayal of bankers as liquidity seekers, excess reserves decline in an elastic manner as deposit levels increase.

Both results are consistent with banking practice under normal conditions; the accumulation of excess reserves cannot be traced back to the traditional or desired-based explanation. Given that a reason to hold excess reserves is to meet possible runs, the expectation of a deposit inflow should reduce the need to hold excess reserves. Yet, the period is one in which excess reserves increased in the face of significant deposit inflows. Thus, if the external conditioning effects of D_t and R_t are consistent with bank behavior under normal circumstances, we must look more closely at the internal costs of converting excess reserves into other assets to understand the run-up in excess reserves.

TABLE 4. PERIOD 1929-1935

Variable	Monetary Policy: Base 1929:7 – 1933:3	Monetary Policy: M1 1929:7 – 1935:8
Constant (α_0)	59.8533	56.0400
	(9.73)	(5.91)
R_t (α_1)	-1.3557	-1.3084
	(4.06)	(1.57)
D_t (α_2)	-5.1391	-4.7229
	(9.11)	(4.73)
MP_t (α_3)	13.1819	57.6137
	(1.49)	(2.61)
SR_t (γ_1)	-1.2606	-.6879
	(3.01)	(2.07)
SD_t (γ_2)	-.1390	-.1353
	(0.07)	(0.07)
SMP_t (γ_3)	5.9342	1.1212
	(3.13)	(0.46)
Stable Root (λ_1)	.5193	.8532
	(4.76)	(15.32)
$\hat{\sigma}$	.2618	.2464
η_1	2.68	2.05
	(0.84)	(0.75)
η_6 (1)	0.0300	3.8000
	(0.86)	(0.05)
ϕ(18)	11.0500	24.3600
	(0.89)	(0.44)

Notes: t-values are reported in parentheses below the corresponding estimates. $\hat{\sigma}$ = standard error of estimate: η_1 = portmanteau Lagrange multiplier test for r-th order residual autocorrelation, distributed as $X^2(r)$ under the null.: η_1 = portmanteau Lagrange multiplier test for r-th order residual autocorrelation, distributed as $X^2(r)$ under the null.: η_6 = ARCH test.: ϕ = Box-Pierce test.

The Role of Internal, or Scale-Related, Adjustment Costs

Separate estimates were made with a dummy variable first dated at 1933:3 and then dated at 1935:8. A banking holiday was declared on March 6, 1933, and an Emergency Banking Act passed on March 9, 1933. The second date coincides with the passage of the Banking Act of 1935 (August 23, 1935). In general, this act concluded a series of reforms that altered the U.S. banking structure.[17]

As stated earlier, the purpose of this paper is to measure the size of internal adjustment costs during the 1930s. This can be accomplished using information from Tables 3 and 4. The estimates in Table 4 provide one contrast in coefficient estimates that is of immediate relevance. Note that $\lambda_1 = .5193$ for the base equation in Table 4 compared to $\lambda_1 = .8839$ in Table 3. The implied weight of $w = w_0/w_1$ may be derived from the relation between λ_1, β, and w.[18] The relation is implied by the fact that $\lambda_1 + \lambda_2 = (1 + \beta + w)/\beta$ and $(1 - \lambda_1)(1 - \lambda_2) = (1 - \lambda_1)\left[1 - (\lambda_1 \beta)^{-1}\right] = -w/\beta$ with $\beta = .997$ and $\lambda_1 = \hat{\lambda}_1$. It can be derived from the results in Table 3 that w = .0156 compared to w = .4463 for Table 4 (1929-1933) for the monetary base equation. Thus, internal asset adjustment costs are about 64 times more important than deviations of actual from target reserve levels over the 1929-1941 period. However, for the 1929-1933 period, adjustment costs are only about 2.7 times as important as the deviation of actual from the target level of excess reserves. These results show that, during the period after the bank holiday, banks faced significantly higher internal costs in making asset adjustments. The costs of deviating from target excess reserves (the term $(XR_t - XR_t^*)^2$ in (2)) were small due to the low interest rates of the period and the falling likelihood of runs the further bankers were from the "holiday." However, the costs of changing excess reserves seen in creating other income-producing assets (the second term in (2), $(XR_t - XR_{t-1})^2$), grew after 1933. Banks faced very large adjustment costs when converting reserves into profitable income earning assets. A rapidly growing level of deposits coupled with very large adjustment costs led to an increasing stock of reserves that constituted unintended inventory. This also points to the case that a monetary stimulus of a given size would have been more effective in the early period. This finding is consistent with the contentions of Friedman and Schwartz, and others, that the Federal Reserve was derelict in not expanding the money supply during the period preceding the Bank Holiday. The failure to act before the Bank Holiday greatly restricted the Federal Reserve's options because, after the Bank Holiday, a banking channel monetary expansion was not likely to have occurred in the face of these large costs of adjustment.

Summary and Conclusions

The behavior of banks during the episode of large and persistent amounts of excess reserves in the 1933-1941 period have interested and puzzled researchers for decades. In other places, arguments have been presented that these excess reserves were sought for protective liquidity or as a signal to depositors that the bank was safe. More recent explanations argue that the excess reserves were an unintended inventory and banks accumulated them because the internal adjustment costs of creating income-producing assets were relatively high.

Results in this paper support the unintended inventory explanation. Internal adjustment costs were found to be very high for the 1934-1941 period and presented a significant obstacle to banks

[17] The fundamental model is stable between the two periods. Tests for stability may be obtained from the authors.

[18] The weights are found in expression 2. See Cuthbertson (1988) for an expanded discussion of this relationship.

who, at the same time, were the recipients of large deposit inflows. Because of these high costs, banks were unable to convert excess reserves into income-earning assets at a rate to match deposit inflows. This is reflected in the large difference in costs of adjustment between the 1929-1993 period and the 1934-1941 period. Internal adjustment costs were much larger in the later period. After the bank holiday in 1933, banks continued to acquire Treasury securities although the supply was decreasing, and the rate of new lending was high albeit from a much smaller base. However, focusing on rates is misleading. The accumulation of reserves was due to volume differences rather than rate differences. While the rate of increase in loans and the growth rate in the economy were both high during this period, the amount of loans and the level of GNP were much lower then in 1929.[19] As a result, deposit inflows overwhelmed the ability of banks to produce income-producing assets. The volume of loans, while increasing, was not sufficiently large to make use of the volume of deposit flows into banks.

These results have important implications for monetary policy. There is little disagreement that the Federal Reserve executed very little in the way of monetary policy, and when it did, it was counter productive. Yet, discussions of successful monetary policy are hypothetical. Nonetheless, it is useful to analyze which monetary policy would be expected to be successful and which would not, given the findings of high asset adjustment costs.

Assuming there is agreement that an expansion of the money supply is a key component in recovering from a depression, there remains the question of which form of money would have been the most efficient bringing about a recovery. The choice is between outside money, defined as money not created through the issuance of private debt, and inside money, which is created through the issuance of private debt. Outside money includes gold, government debt backed money, and fiat money. Inside money is made up of deposits at banks.

An increase in inside money can occur only if the private sector is willing to borrow and if the banking system is willing to lend. Outside money can be increased without regard to the private sector's borrowing and lending decisions. The results in this paper, together with the work of Bernanke (1983, 1995) and Bernanke and Gertler (1990) detailing the financial fragility in the economy, strongly suggest that a monetary policy utilizing inside money would be ineffective. A policy that depended on the lending of banks as a mechanism to expand the money supply would not be successful.

A successful monetary policy would require a large infusion of outside money either in the form of gold increases or the creation of fiat money. Indeed, as documented by Romer (1992), the recovery from 1934 through 1941 was fueled by an influx of gold that was not sterilized by the Treasury. Adding to the gold inflows was an infusion of three billion dollars of fiat money as a result of the Thomas Amendment to the Agriculture Adjustment Act (Friedman and Schwartz 1963).

The results of this paper also point out the importance of analyzing banks in a production model rather than a portfolio model. Banks produce loans for borrowers who, for the most part, do not have access to primary and secondary financial markets. Producing loans requires resources to evaluate credit worthiness and loan monitoring as well as other processing activities. This activity requires plant, equipment, and employees as well as reserves. By 1934, there were one-third fewer banks than before the crash. Moreover, the remaining banks often operated in markets that restricted branching, and the number of banks did not change greatly during the period.[20]

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[19] Mounts, Sowell and Saxena (2000) find that loans increased in country member banks in nine of the 12 Federal Reserve Districts after 1936 at a faster rate than during economic expansions in the 1920s. Romer (1992) documents the high rate of growth during the recovery.

[20] The number of banks between 1933 and 1941 range from a low in 1941 of 14,825 to a high of 16,096 in 1934. The average of the period was 15,339 with a standard deviation of only 458.

Because of these factors, it is likely that banks were producing loans at a full-capacity level based on their level of "plant and equipment." Thus, to expand the money supply rapidly through the private lending process would have required a large increase in banks' physical capital and an expansion of existing banks into new (for an individual bank) geographic markets. In an environment where the rate of loan growth was higher than "normal" and banks were recovering from the worst bank failure experience in a century, it is difficult to imagine banks aggressively expanding markets and investing in bricks and mortar.

References

Bernanke, Ben S. 1983. "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression." *American Economic Review* 73: 257-76.

Bernanke, Ben S. 1995. "The Macroeconomics of the Great Depression: A Comparative Approach." *Journal of Money, Credit and Banking* 27: 1-28.

Bernanke, Ben S., and Mark Gertler. 1990. "Financial Fragility and Economic Performance." *Quarterly Journal of Economics* 105: 87-114.

Board of Governors of the Federal Reserve. 1943. *Banking and Monetary Statistics.* Washington, D.C.

Breusch, T. S., and A. R. Pagan. 1980. "The Lagrange Multiplier Test and its Application to Model Specification in Econometrics." *Review of Economic Studies* 47: 239-253.

Calomiris, Charles W., and Berry Wilson. 1996. "Bank Capital and Portfolio Management: The 1930s Capital Crunch and Scramble to Shed Risk." In *Rethinking Bank Regulation: What Should Regulators Do?* Thirty Second Annual Conference on Bank Structure and Competition (Federal Reserve Bank of Chicago): 515-530.

Cuthbertson, Keith. 1988. "The Demand for M1: A Forward Looking Buffer Stock Model." *Oxford Economic Papers* 40: 110-131.

Cuthbertson, Keith, and Mark P. Taylor. 1987. "The Demand for Money: A Dynamic Rational Expectations Model." *Economic Journal* 97 Supplement: 65-76.

Cuthbertson, Keith, and Mark P. Taylor. 1989. "Anticipated and Unanticipated Variables in the Demand For M1 in the UK." *Manchester School of Economics and Social Studies* 57: 319-39.

Davidson, James E., David F. Hendry, Frank Srba, and Stephen Yeo. 1978. "Econometric Modelling of the Aggregate Time-Series Relationship Between Consumers' Expenditure and Income in the United Kingdom." *Economic Journal* 88: 661-692.

Dickey, David A., and Wayne A. Fuller. 1981. "Likelihood Ratio Statistics for Autoregressive Time-Series With a Unit Root." *Econometrica* 49: 1057-1072.

Engle, Robert F. 1982. "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation." *Econometrica* 50: 987-1007.

Ferderer, J. Peter, and David A. Zalewski. 1994. "Uncertainty as a Propagating Force in the Great Depression." *Journal of Economic History* 54: 825-49.

Friedman, Milton, and Anna J. Schwartz. 1963. *A Monetary History of the United States 1867-1960.* Princeton, NJ: Princeton University Press.

Frost, Peter A. 1971. "Banks' Demand For Excess Reserves." *Journal of Political Economy* 79: 805-825.

Godfrey, Leslie G. 1978. "Testing Against General Autoregressive and Moving Average Error Models When the Regressors Include Lagged Dependent Variables." *Econometrica* 46: 1293-1301.

Hall, Stephen G., S., G. B. Henry, and Simon Wren-Lewis. 1986. "Manufacturing Stocks and Forward Looking Expectations in the UK." *Economica* 53: 447-465.

Hansen, Lars Peter, and Thomas J. Sargent. 1981. "Linear Rational Expectations Models for Dynamically Interrelated Variables." In *Rational Expectations and Econometric Practice*, edited by Robert J. Lucas and Thomas J. Sargent. Minneapolis: University of Minnesota Press.

Mason, J., Ali Anari, and James Kolari. 2000. "The Speed of Bank Liquidation and the Propagation of the Great Depression." In *The Changing Financial Industry and Regulation: Bridging States, Countries and Industries*, Thirty Sixth Annual Conference on Bank Structure and Competition (Federal Reserve Bank of Chicago).

Mounts, W. Stewart, Clifford B. Sowell. and Atul K. Saxena. 2000. ""An Examination of Country Member Bank Cash Balances of the 1930s: A Test of Alternative Explanations." *Southern Economics Journal* 66: 923-941.

Morrison, George R. 1966. *Liquidity Preferences of Commercial Banks*. Chicago, IL: University of Chicago Press.

Ramos, Alberto M. 1996. "Bank Capital Structures and the Demand for Liquid Assets." In *Rethinking Bank Regulation: What Should Regulators Do*? Thirty Second Annual Conference on Bank Structure and Competition (Federal Reserve Bank of Chicago): 473-501.

Romer, Christina D. 1992. "What Ended the Great Depression." *Journal of Economic History* 52, 757-784.

Sargent, Thomas J. 1987. *Macroeconomic Theory*. 2nd ed. Orlando, FL: Academic Press.

Sealey, C. W., Jr., and James T. Lindley. 1977. "Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions." *Journal of Finance* 32: 1251-1266.

Warburton, Clark. 1950. "The Theory of Turning Points in Business Fluctuations." *Quarterly Journal of Economics* 64: 525-549.

White, Halbert. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48: 817-838.