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PRICE FLEXIBILITY, CREDIT AVAILABILITY, AND ECONOMIC FLUCTUATIONS: EVIDENCE FROM THE UNITED STATES, 1894–1909*

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The importance of disturbances in financial markets for real economic activity and the positive association between price level and output movements typically are explained by appeal to a combination of nominal aggregate demand shocks (particularly money-supply shocks) and rigid prices. We argue that this view is inconsistent with evidence for short-run responsiveness of prices and gold flows to nominal disturbances during the pre-World War I gold-standard era. We offer an alternative explanation that connects financial markets and real activity through disturbances to the availability of credit. This approach links comovements in prices and output through real effects in credit markets associated with price-level shocks. Empirical analysis, using monthly data for the pre-World War I period, supports the assumption of rapid price adjustment, and the credit-supply interpretation of the transmission of financial shocks. Disturbances to credit availability, including price shocks, contribute substantially to our empirical explanation of output fluctuations during this period.

I. INTRODUCTION

This paper examines the role of credit channels in explaining cyclical fluctuations in a regime of flexible prices. The standard framework used to explain observed links between financial shocks

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and real activity and the correspondence between price and output movements during the period prior to World War I—a framework that includes rigid prices and inelastic money supply—is inconsistent with evidence that prices were relatively flexible and that money per se was supplied elastically. We posit and test an alternative explanation of these facts that emphasizes real credit-supply shocks, and a credit-market transmission mechanism that links the price level, real income, and loan supply. Our findings in support of this alternative view suggest that conclusions based on views of the transmission of economic fluctuations solely through nominal rigidities in product or labor markets may be misleading.

Our effort is empirical, and focuses on aggregate data for the United States under the pre-World War I gold standard, prior to the operation of the Federal Reserve System. Fluctuations in output were pronounced in the last half of the nineteenth century and the early years of the twentieth century. This period saw greater variability of output and duration of cycles than the extensively studied modern period (see Burns [1960], Gordon [1980], Sachs [1980], James [1985], DeLong and Summers [1986], Taylor [1986], Zarnowitz [1985], and Miron [1986]).[1] For our empirical work we constructed a monthly data base on real and financial variables covering the period from 1894 to 1909 (see the detailed description in the Appendix).[2]

Recent research on short-run adjustment during this period (reported in Calomiris and Hubbard [1987a]) indicates that the responses of gold flows to monetary disturbances were rapid, and the supply of transacting balances was endogenous even in the short run. Event analysis of panic episodes, ARMA representations of gold flows, and macroeconomic simulation models of international adjustment using monthly data all indicate that adjustment to transaction-balance shocks was essentially complete within three months. Moreover, commercial paper rates across countries were closely linked, and traded goods prices were highly responsive in the short run to international supply and demand disturbances. This research confirms previous evidence of a relatively high degree of money-supply price-level responsiveness for this period, and seems

1. Romer [1986] has challenged the view that early business cycles were so volatile. Her reinterpretations of the data on employment, output, and industrial production provided by Lebergott, Kuznets, and Frickey, respectively, have in turn been challenged by Weir [1986], Lebergott [1986], and Balke and Gordon [1989]. None of Romer's suggested adjustments, however, would indicate that historical business cycles were less or equally severe than those of the post-World War II era.

2. Previous studies have relied largely on annual data. The more frequently collected data reported by the Comptroller of the Currency (see, for example, Gorton [1985]) are not evenly spaced.

inconsistent with the "sticky-price, nominal-shock" interpretation of the business cycle.[3]

We examine the potential real effects of a variety of credit-supply disturbances, and the link between price shocks and output in Section III. We focus on short-run dynamics of inflation, output, and credit-market variables. We employ the "structural VAR" approach of Blanchard and Watson [1986], Bernanke [1986], and Sims [1986], permitting us to solve a simultaneous-equations model in variables' innovations.

Our results confirm the responsiveness of prices in the short run. In particular, prices did not lag related movements in output. Furthermore, price shocks had important and persistent effects on output (see also DeLong and Summers [1986]). We argue that price shocks were associated with credit-supply disturbances, and we find that disturbances to the real supply of credit other than those associated with price shocks were important determinants of output as well. Our findings suggest that financial disturbances operated through real effects on the cost of credit supply, and that the observed positive association between output and price changes in annual contemporaneous data for the pre-World War I period (see, for example, Gordon [1980] and James [1985]) reflects the impact of price shocks and credit availability on output, rather than the lagging response of prices to nominal aggregate demand shocks. We do not argue for a strict "banking panic" view of the importance of credit shocks (see also the arguments of Cagan [1965], DeLong and Summers [1986], Gorton [1985], and Bordo [1985]);[4] we allow for local changes in credit supply as well as extreme cases associated only with systematic collapse.[5]

3. Early evidence on price flexibility for many commodities during the period is presented in Mills [1927]. The lack of short-run price predictability for this period has been demonstrated by Klein [1975], who notes significant negative autocorrelation in rates of price change. Rockoff [1984] argues that reactions in international gold supply served to reverse short-run changes in commodity prices in the long run. In Calomiris and Hubbard [1987a], we show that prices were closely linked across international markets over short-time horizons. Foreign commodity prices were not always a binding constraint on domestic prices; transport costs and tariffs provided a range of domestic price autonomy. Reactions to movements in international prices which tripped these cost thresholds, however, were rapid. In macroeconomic simulation models, price adjustment occurs rapidly in response to disturbances, including those to export and import demands and desired net foreign savings.

4. Historical accounts (e.g., the classic studies of Bagehot [1973], Sprague [1910], and Mitchell [1913]) usually point to "financial panics" before the creation of the Federal Reserve System, though little effort is made to connect instability in financial markets per se with macroeconomic variables.

5. It is important to note that these arguments are made against a background of a passive credit-supply policy. The presence of an active lender of last resort for banks might forestall much of the credit constraints and illiquidity accompanying deflation in our model.

International asset-price linkages and elastic gold flows argue against viewing

In Section IV we argue that an emphasis on financial disturbances and debt deflation is consistent with evidence of greater frequency and independence of U. S. business cycles during the silver crisis years, and closer international comovements of output after the turn of the century.

Some conclusions and implications are discussed in Section V.

II. Price Flexibility, Credit Markets, and Economic Activity

A. Background

Most previous discussions of links between banking system instability and output fluctuations during our period of study can be divided into two principal camps with respect to their assumptions about price flexibility. The first—the "monetarist" approach associated with Friedman and Schwartz [1963] and Cagan [1965]—considers "bank panics" to be important because of their effect on the nominal money stock and hence (if prices are sticky) on real activity.[6] A second school of thought—identified with Fisher [1933], Minsky [1975, 1977], and Kindleberger [1978]—focuses on price flexibility and "debt deflation" as a link between financial crises and economic activity; emphasis is placed on an irrational boom and bust cycle.[7] Neither of these lines of inquiry provides a convincing explanation of the relationships among contractual arrangements (in labor, product, and credit markets), banking panics, and output fluctuations.[8]

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the establishment of the Federal Reserve as an important event with respect to the money supply process per se, but the Fed's role as lender of last resort to banks may have mitigated the effects of liquidity constraints. The availability of the discount window permitted banks to economize on precautionary reserve holdings, and made loan supply more elastic. That is, the Fed provided a form of "liquidity insurance" against unpredictable depositor withdrawals that allowed banks better to accommodate seasonal swings in the demand for loans. Thus, Miron's [1986] findings of reduced business-cycle risk after the establishment of the Fed may be reconciled with the findings of Clark [1986], Officer [1986], and Calomiris and Hubbard [1987a], discussed below. Of course, as the 1930s show well, nothing about the existence of a central bank guarantees that these problems will be mitigated.

6. Friedman and Schwartz and Cagan focus on the decline in public confidence in the banking system attendant to panics, which raises the currency-deposit ratio and the reserve-deposit ratio, and precipitates a decrease in the nominal money supply.

7. The cycle is described by a process in which upswings encourage excessively sanguine views, "overindebtedness," illiquidity, and eventually banking crises, as deflationary pressures from liquidation raise the real value of nominal debt commitments. Reductions in the price level bring about increases in real interest rates and decreases in net worth and profits. Recovery is brought about when overindebtedness is eliminated or policy stimulus is applied. The cycle then repeats itself.

8. For example, against the Fisher-Minsky school, Cagan [1965] finds that U. S.

DeLong and Summers [1986] challenge the two schools of thought by emphasizing a link between deflation and output through the real interest rate. They argue that deflationary shocks increase real interest rates because nominal interest rates are sticky. A decline in aggregate demand should follow. While their argument focuses on the important link between price flexibility and connections between financial-market outcomes and real activity, two qualifications are in order. First, interpretation of the real-interest-rate effect described by DeLong and Summers is difficult. As we shall argue later, movements in commercial paper rates (their measure of the cost of credit) may not fully reflect the shadow price of funds in the banking sector. We present additional evidence on this point in Section III. Second, the notion that unresponsive nominal interest rates caused changes in real rates seems inconsistent with evidence for gold interest rate parity (see Calomiris and Hubbard [1987a]). In the historical gold-standard regime interest rates across countries responded to one another's changes to preserve a nearly common real rate for high-grade, liquid commercial paper.

Finally, the link between financial disturbances and real activity may reflect real changes in the cost of supplying credit. This view also posits a link between price and output changes which operates through the effect of price changes on the cost of credit. Bernanke [1981, 1983] provides an analytical foundation for the debt-deflation view, connecting deflationary shocks and the rising

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panics did not in general foreshadow cyclical downturns; see also Bordo [1985] and Gorton [1985]. Fisher and Minsky do not explain the persistence of irrationality or the precise channels through which the degree of price flexibility in the economy and the way in which banks adjust to shocks are related.

The monetarist approach depends both on sluggish gold flows and price rigidity to transform money-multiplier shocks into real effects. This liquidity-preference transmission mechanism is, however, difficult to reconcile with the evidence for responsive gold flows (short-run endogenous monetary adjustment), asset-price linkages, and commodity price flexibility in the nineteenth and early twentieth centuries. Clark [1986] finds a close correspondence in seasonal interest rate patterns internationally, and Officer [1986] shows that gold points virtually were never violated during this period. In Calomiris and Hubbard [1987a]—using data on bill-of-exchange prices, spot exchange rates, and prime-quality commercial paper rates—we demonstrate that interest rate parity held closely between London and New York and that gold flows did not respond "sluggishly" to fundamentals. Currency risk associated with the silver movement in the 1880s and 1890s is responsible for wide interest differentials observed during this period.

Contemporary accounts emphasized the credit (as opposed to the liquidity-preference) transmission mechanism. Brown [1910, p. 748] notes: "... it is not the saving of capital in the form of coinage which brings after it a lower rate of interest. Rather is it, that either is absolutely conditional on the other, that the lower interest charge made possible by the banking function enables bank credit, in open competition, to substitute itself for cash, or induces among banks the policy of lending in general only their own credit."

"cost of credit intermediation" during financial crises (see also Hamilton [1987]). Under nominal financial contracting, unanticipated deflation reduces the net worth or borrowers as it increases the real value of nominal debt. Thus, deflation can cause borrowers to default and banks to fail. More generally, deflation increases the default risk on bank loans and deposits. This in turn can cause disintermediation by depositors, which reduces the real amount of funds available for banks to lend. The reduction in borrowers' net worth also reduces the attractiveness of making new bank loans to "information-intensive" borrowers. For these borrowers, access to funds is limited to banks (who specialize in monitoring them), and this access depends on borrowers' ability to commit (through limited leveraging) to sharing in possible losses on risky investments. Reductions in borrowers' net worth, therefore, limit the extent of self-finance and the access to bank credit.[9]

Thus, during a deflationary episode borrower and bank defaults rise, real deposits shrink, and loan supply to information-intensive borrowers falls by even more than deposits as banks limit their risk by increasing the ratio of reserves to loans. This view of the link between price and output movements, therefore, posits a financial channel that depends on the allocative effects of wealth redistributions under imperfect capital markets. Deflationary shocks reduce the supply of credit to some classes of borrowers, and such reductions have real effects.

Debt deflation is not, however, the only means by which deflationary shocks can be linked to credit-supply disturbances. Deflationary shocks may simply reflect adverse credit-supply disturbances, rather than cause them. For example, under the gold standard any unanticipated decline in the demand for commodities, or financial assets, relative to gold would have caused a deflationary shock. While international asset and commodity linkages limited such movements, they did not eliminate them. Such demand shocks were associated with bank disintermediation (as during the flight from the dollar during the silver crises of the 1890s), and reflected reductions in the real supply of credit for some borrowers.

The existence of capital-market imperfections that propagate, or are reflected in, deflationary shocks also implies real effects from other disturbances to borrowers' net worth, and to the available supply of bank loans, that are not captured by deflation shocks

9. For examples of models that link borrowers' wealth with access to funds, see Stiglitz and Weiss [1981], Calomiris and Hubbard [1987b], Bernanke and Gertler [1987], and Williamson [1987].

alone. In general, "the" interest rate will not be a sufficient statistic for the shadow price of credit. Most models here stress the importance of borrowers' internal finance (net worth) and the condition of banks for the pricing and availability of credit. The central idea is that certain classes of borrowers—those for whom the added costs of finance induced by incentive problems under asymmetric information are large relative to their funding needs—may find it prohibitively expensive to obtain financing by issuing securities on the open market. Bank monitoring of information-intensive firms can mitigate the problems of asymmetric information, and give firms access to external funds. Thus, for firms with little (or no) access to direct credit, the terms under which bank credit is available are an important determinant of investment. In general, these terms will involve quantity constraints on borrowing, as well as stipulating the cost of funds (see Stiglitz and Weiss [1981], Calomiris and Hubbard [1987b], and Bernanke and Gertler [1987]).

In summary, an emphasis on credit-supply disturbances in a regime of flexible prices and elastic money supply leads one to view the cyclical association between the price level and output as mainly reflecting output responses to credit-supply disturbances that are associated with price-level shocks. To measure the importance of shocks to the cost of credit on economic activity, it is necessary to include various cost measures, including interest rates, the flow of loans in nonprice-clearing, information-intensive markets, and measures of disturbances to information-intensive borrowers' net worth (which includes unanticipated deflation).

B. Historical Perspective

Annual data on real output and price level movements, bankruptcies, and bank failures are consistent with an emphasis on real credit-supply shocks, though the use of annual data precludes isolating channels of cause and effect. Figure I illustrates the parallel movements in output and price, and their negative association with bank failures and bankruptcies.

Though changes in the annual average price level appear small in relation to output changes during the recessions of 1892–1894, 1895–1996, and 1907–1908, two points warrant mention: first, more severe short-run price volatility (which is more relevant for short-term debt financing) is hidden by the annual averages. For example, while annual averages show a price decline of only 1.3 percent for 1895–1996, prices fell at an annualized rate of greater than 12

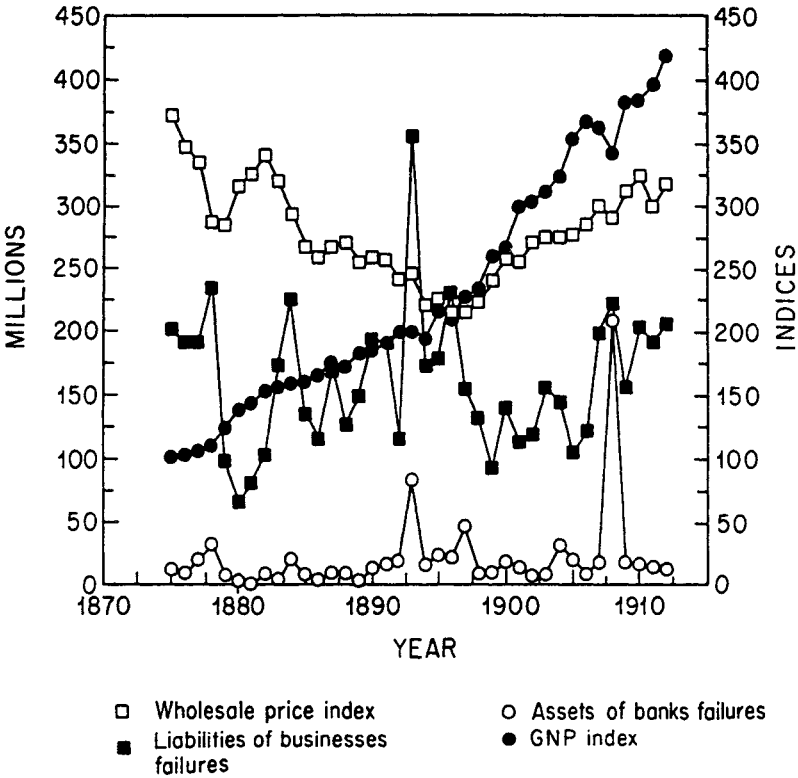

FIGURE I
Sources. See Data Appendix.

percent in the first six months of the year. Second, price *shocks* refer to the difference between realized and expected levels. During the silver crises and recessions of 1893 and 1896 inflation expectations (that is, forward exchange rate premiums) were high; the fact that "free silver" forces lost political battles in 1893 and 1896 caused ex post redistributions of wealth away from debtors when inflationary expectations were not realized (see Calomiris and Hubbard [1987a]). In contrast, during the *predictable* deflation of 1877–1878, which accompanied expected resumption of specie convertibility in 1879, price declines did not disrupt financial markets, and output rose (see Calomiris [1988]).

These links among deflation shocks, price flexibility, and the provision of bank credit were not lost on contemporary chroniclers; indeed, illustrations of the transmission mechanism abound. Analyses in the *Commercial and Financial Chronicle* are typified by the

following: "The effect of the unstable paper currency in checking the credit system, and forcing cash transactions upon the business community, is very apparent in the returns made by the number of failures, and the amount of their liabilities, in the past few years" [February 1865, p. 113].

Furthermore, evidence of rationing of credit to worthy borrowers appeared frequently in the writings of contemporaries. For example, Persons [1920] discusses the link between deflation and credit market instability, and Brown [1910], Laughlin [1910], and Kemmerer [1910] all were careful to identify links from deposits through bank credit (and specifically *not* the money supply) to economic activity. Stevens [1894, p. 133] notes that many solvent businesses closed during the panics of 1884 and 1893, and [p. 140] that wholesale business done on a credit basis prior to the panics was done on a cash-only basis. That the rationing of longer term loans accompanying deflation in commodity prices led to more extensive and expensive reliance on short-term paper is noted as far back as 1865 by the *Commercial Chronicle and Review of Hunt's Merchants' Magazine*. Sprague's [1910] study reflects these same themes: "It would seem, then, that business distress from lack of credit facilities was due to at least three influences: the restriction of cash payments by the banks' increased the requirements of borrowers; the supply of loans was reduced by a moderate amount of contraction; and the shifting of loans involved considerable uncertainty and inconvenience" [pp. 302–03]. Examples of the importance of credit rationing and credit market segmentation appear frequently in Sprague:

> Their loans also must have been of *high average quality* after four years of thoroughgoing liquidation and recuperation in the business world [p. 217, emphasis added].
>
> . . . it is certain that the demand for additional capital was outstripping current savings seeking investment. Increasing difficulty was experienced in marketing securities *of the highest class* [p. 237, emphasis added].
>
> Whatever the causes, the inability to secure capital by the sale of securities in a period of active business should have been enough in itself to inspire unusual caution in the management of banking institutions. When corporations of the highest standing are obliged to resort to short-term notes it may be assumed without question that other corporations are expanding upon an insufficient foundation of working capital, that current obligations are increasing, and that bank credits are being used to their utmost extent [p. 238].
>
> Borrowers are forced to resort almost entirely to their own banks. . . . This shifting of loans involves much strain and uncertainty and in many instances it is not possible to carry it out at all [p. 302].

Three economic themes emerge clearly from this historical discussion. First, there appears to be sequential market clearing, in

which credit markets close down, starting with those for lowest quality borrowers and moving to those for higher quality borrowers. Second, the use of short-term credit is one means of rationing available credit to some high-quality borrowers. These phenomena are particularly visible during the Panic of 1907 when credit became increasingly quantity-rationed and short-term. Bank loans of greater than 90 days were unavailable in November and December 1907, while interest rates on short-term loans and commercial paper rose to two and three times their normal ranges.[10] Perhaps most important for our analysis, contemporaries recognized a link between deflationary shocks and the rationing of credit—(i) from the public to the banking system (through a decrease in deposits) and (ii) from the banking system to information-intensive borrowers (through a reduction in loans relative to reserves, and quantity rationing to low-quality borrowers). In the next section we test for the real effects of this rationing, examining links between price shocks and economic fluctuations and the importance of credit channels.

III. Measuring the Real Effects of Credit Supply Shocks

As we have argued, in a world with heterogeneous borrowers and capital-market imperfections, focusing on one interest rate to represent the shadow price of credit is inappropriate. The true shadow price of credit to a borrower reflects the cost of funds, as well as limits on the quantity of funds that can be borrowed on those terms. Lending costs will reflect not only the underlying risk of projects, but the costs associated with information asymmetry in the credit market. Borrowers of differing qualities will have differential access to credit, with credit rationing of distressed firms increasing during financial stringency (see Bernanke [1983]; Calomiris, Hubbard, and Stock [1986]; and Fazzari, Hubbard, and Petersen [1988]). For example, Bernanke [1983] notes that banks held substantial excess reserves during the depth of the Great Depression of the 1930s, when many firms' unsatisfied demands for credit were high.

For our empirical work we construct a set of instruments for credit scarcity. These instruments approximate the difference between the low-risk cost of capital under full information and the various actual costs of borrowed funds. In addition to the lowest

10. Data on loan rates of different maturities are from National Monetary Commission, *Statistics of the United States.*

risk commercial paper rate, we consider three types of measures: (i) the interest rate differential for commercial paper of different "quality," (ii) the quantity of credit available through the banking system, and (iii) proxies for deterioration of firms' net worth (price shocks and business failures). Detailed descriptions of the construction of the variables are presented in the Appendix.

First, we include the differential between end-of-month "single-name, good" commercial paper of 4–6 months maturity (i^{cg}) and "single-name, prime" commercial paper of 4–6 months maturity (i^{cp}). This spread reflects the interest premium charged on paper of lower quality but similar maturity.[11] Inclusion of such interest differentials provides a measure of the relative cost of risky loans, which presumably rises in response to economy-wide credit contraction, as well as deterioration in the financial positions of risky borrowers. That is, the rise in the cost of funds for the highest quality borrowers in response to a general credit-supply contraction will be relatively small, as they have special access to multiple (international) sources of credit.

That the various commercial paper rates may be imperfect indicators of the cost of credit implies that quantity flows may contribute explanatory power at the margin above that contributed by the price of funds. For this reason we include the real change in loans $(L_t - L_{t-1})/P_{t-1}$, where L and P denote the stock of loans and the price level, respectively.[12] The real flow of loans should not be viewed as a proxy for a money supply disturbance because, as we have argued, responsive endogenous money flows insulated the economy from disturbances in the supply of transactions balances per se.[13]

Finally, we also consider the monthly percentage change in the liabilities of business failures; this variable is constructed from the monthly series reported by Dun and Company. The business-

11. Descriptions of the various commercial paper securities can be found in James [1978]. Essentially, single-name paper is the liability of an individual borrowing to secure working capital. Double-name paper is usually the liability of both parties involved in a commercial transaction for which trade credit is needed.

12. As a further indication of the cost of intermediation, the reserve-loan ratio serves as a measure of credit rationing, that is, of bankers' desires to reduce the supply of credit given the reserves available. The variable contains information on shocks to the banking system; disintermediation will likely lead to an increase in the reserve-loan ratio. In addition, the shortfall of bank reserves relative to desired levels signals the potential for loan contraction and liquidation. In our empirical work we obtained similar results using the aggregate bank reserve-loan ratio instead of using the real flow of bank loans.

13. Rush [1985] provides additional evidence that money shocks per se were not important for explaining cyclical behavior in the U. S. economy during our period, while the extent of financial intermediation was important.

failures variable serves as a (threshold) proxy for the more general erosion of borrowers' collateral and the increased riskiness of bank portfolios both of which are associated with reduced loan supply.[14] The inclusion of failures in the models we estimated uniformly increased the statistical significance and economic importance of the effects of inflation on output.[15]

Our sample period, 1894–1909, is dictated by the availability of monthly data on interest differentials and liabilities of failed businesses. This is a peacetime period for the U. S. during which countercyclical fiscal and monetary policy intervention was negligible.

For output we used pig iron production.[16] The well-known Persons [1931] index of industrial production relies mainly on bank clearings and other variables of questionable relevance for output. Another alternative, the level of imports, is unattractive for our purposes because price effects on imports are contaminated by the terms-of-trade effect. Pig iron is highly correlated (with a correlation coefficient of 0.84 in *growth rates*) with total nonagricultural commodity output, on an annual basis.[17] Hull [1911] argues that iron was used historically as a leading indicator (the "barometer of trade") because of its ubiquitous presence as an input.

To test for the effects of price shocks and credit availability on output described above, we examine dynamic relationships among the price level, output, and financial variables.[18] We adopt an approach recently developed by Blanchard and Watson [1986], Bernanke [1986], and Sims [1986] as an alternative to "reduced-form" recursive identification of disturbances. This alternative "structural VAR" approach permits one to solve a simultaneous-equations model in innovations in which orthogonalized shocks and their interrelations are associated with *functions*, not with *variables*. The first stage of a structural VAR model is identical to a

14. Gorton [1985] finds liabilities of failed business to be a significant factor in explaining the riskiness of bank deposits and the banking system's currency-deposit ratio.

15. For example, adding failures to a standard VAR model of output growth, inflation, and the low-risk interest rate roughly doubles the contribution of shocks to inflation to the explanation of the long-run forecast variance of output.

16. For a description of the cyclical properties of various output measures over our period of study, see Eckler [1933].

17. Annual nonagricultural commodity output is derived from Shaw [1947] and defined as the constant dollar sum of producer durables, consumer durables, semidurables, and construction materials.

18. Time, time squared, the tariff on pig iron, and seasonal dummies are included as independent variables in the estimation equations. Miron [1986] has emphasized the potential importance of seasonal fluctuations in financial variables during this period. The inclusion of seasonal dummies is the appropriate way to take account of the patterns (see Porter [1985, p. 136]).

standard VAR: lagged values of all variables are included to calculate reduced-form predictions, to generate causality tests, and to derive series of unpredicted innovations (which are correlated across variables). In the next stage we posit a matrix of functional relationships, which can be tested and which produce orthogonalized shocks to the hypothesized functions.

We then calculate impulse responses of each variable in the system to shocks that originate in particular functions, and decompositions of each variable's forecast variance, which attribute uncertainty regarding the future of any particular variable to each of the functional shocks. Impulse responses and variance decompositions together permit one to infer the time path of a given shock's influence on all variables, as well as its economic importance.

In Tables I and II we present results for a structural VAR model which includes the four credit measures suggested in Section II. The reduced-form estimation for the model includes eight lags of the following variables: the real flow of loans $[(L - L_{-1})/P_{-1}]$, the "double-name" commercial paper rate (i^c), the interest differential between "single-name, good" and "single-name, prime" commercial paper of 4–6 months maturity ($i^{cg} - i^{cp}$), the rate of change of the wholesale price index, the growth rate of pig iron production, and the percentage change in the liabilities of business failures.

The correlation matrix for the residuals is given in Table I. The signs of these simple correlations provide prima facie evidence of the potential importance of credit-supply disturbances for price and output movements. Output residuals are positively correlated with real-loan and price residuals, and negatively correlated with interest-rate and business-failure residuals. Unanticipated inflation is negatively correlated with unanticipated business failures and risk premium residuals. Failure residuals are positively correlated with the residuals of the low-risk interest rate and the risk premium.

The structural VAR model we apply to these residuals takes the form,

$$\lambda = -a_1\delta - a_2\theta + \lambda^*, \tag{1}$$

$$i = -b_1\lambda + i^*, \tag{2}$$

$$\delta = c_1 i - c_2\pi + c_3\theta + \delta^*, \tag{3}$$

$$\pi = d_1 i - d_2\delta - d_3\theta + \pi^*, \tag{4}$$

$$\gamma = e_1\lambda - e_2 i - e_3\delta + e_4\pi - e_5\theta + \gamma^*, \tag{5}$$

$$\theta = g_1 i + \theta^*. \tag{6}$$

TABLE I

VAR ESTIMATION RESULTS: INTEREST RATES, INFLATION, OUTPUT GROWTH, BANK LOANS, INTEREST DIFFERENTIALS, AND LIABILITIES OF FAILURES (MONTHLY, 1894: 10-1909:12)

F-test: Significance levels Contemporaneous / Lagged	$\frac{L - L_{-1}}{P_{-1}}$	i^c	$i^{cg} - i^{cp}$	$\frac{\dot{p}}{p}$	$\frac{\dot{y}}{y}$	$\frac{\dot{f}}{f}$
$\frac{L - L_{-1}}{P_{-1}}$	0.611	0.293	0.927	0.568	0.091	0.079
i^c	0.115	0.000	0.095	0.159	0.102	0.012
$i^{cg} - i^{cp}$	0.888	0.023	0.000	0.269	0.838	0.089
$\frac{\dot{p}}{p}$	0.939	0.803	0.017	0.669	0.033	0.213
$\frac{\dot{y}}{y}$	0.840	0.350	0.494	0.181	0.000	0.394
$\frac{\dot{f}}{f}$	0.742	0.230	0.074	0.528	0.078	0.000
Correlation matrix of residuals						
$\frac{L - L_{-1}}{P_{-1}}$	1.00					
i^c	−0.41	1.00				
$i^{cg} - i^{cp}$	−0.07	0.16	1.00			
$\frac{\dot{p}}{p}$	−0.07	0.003	−0.12	1.00		
$\frac{\dot{y}}{y}$	0.17	−0.33	0.01	0.22	1.00	
$\frac{\dot{f}}{f}$	−0.07	0.14	0.13	−0.16	−0.20	1.00

Variable Definitions

L = stock of loans outstanding in major cities

i^c = commercial paper rate ("double-name, choice")

i^{cg} = commercial paper rate ("single-name, good")

i^{cp} = commercial paper rate ("single-name, prime")

$\frac{\dot{p}}{p}$ = rate of change in the wholesale price index

$\frac{\dot{y}}{y}$ = rate of growth of pig iron production

$\frac{\dot{f}}{f}$ = rate of growth of liabilities of failed business.

TABLE II
RESULTS FROM STRUCTURAL VAR MODEL

Coefficient estimates

(1) $\lambda = -0.001\ \delta - 0.023\ \theta + \lambda^*$
(0.084) (0.113)

(2) $i = -0.766\ \lambda + i^*$
(0.123)

(3) $\delta = -0.070\ i - 0.084\ \pi + 0.144\ \theta + \delta^*$
(0.041) (1.000) (0.099)

(4) $\pi = 0.0001\ i + 0.007\ \delta - 0.011\ \theta + \pi^*$
(0.002) (0.004) (0.005)

(5) $\gamma = 0.005\ \lambda - 0.028\ i + 0.010\ \delta + 0.727\ \pi - 0.031\ \theta + \gamma^*$
(0.013) (0.007) (0.013) (0.265) (0.017)

(6) $\theta = 0.050\ i + \theta^*$
(0.028)

(Standard errors are in parentheses. Variables describing the innovations are defined in the text. Note that i and δ are measured in units 100 times that of π.)

Decompositions of long-run forecast variance (30 months)

Shocks to / Shocks from	$\frac{L - L_{-1}}{P_{-1}}$	i^c	$i^{cg} - i^{cp}$	$\frac{\dot{p}}{p}$	$\frac{\dot{y}}{y}$	$\frac{\dot{f}}{f}$
λ^*	77.19	22.28	10.74	7.15	10.58	5.31
i^*	7.66	59.03	8.50	6.46	16.89	5.22
δ^*	3.26	2.04	63.67	6.06	0.78	5.22
π^*	2.24	0.90	6.79	70.46	8.87	7.09
γ^*	4.42	12.06	4.71	4.56	52.96	2.08
θ^*	5.23	3.69	5.57	5.31	9.92	75.07

In this model an asterisk indicates an orthogonalized disturbance. λ, i, δ, π, γ, and θ are the residuals from the estimation equations for loans, the low-risk commercial paper rate, the interest rate differential, inflation, output growth, and business failure growth. All coefficients—a_i, b_i, c_i, d_i, e_i, g_i—are assumed positive. A system of six equations allows the estimation of twenty-one parameters (including the six orthogonalized shock variances), so our model is just identified. The structure of the model is discussed below.

Equation (1) is the loan-supply shock function, under the assumption that innovations in real loans supply are primarily a function of the loan-risk proxies (δ and θ) and exogenous supply disturbances.

Equation (2) assumes that innovations to the low-risk interest rate (i^c) stem from changes in the scarcity of domestic bank loans (through spillover effects in credit demand), or exogenous changes

(i^*). i^* shocks include influences on real interest rates and increases in nominal interest rates attributable to currency risk (anticipated appreciation of the dollar due to increased likelihood of conversion to a silver numéraire).

Equation (3) assumes that the risk differential increases as the result of economy-wide increases in credit scarcity (as argued above), and rises when deflationary shocks, or other shocks to borrowers' net worth, lead to increases in the cost of funds for "information-intensive" firms.

Equation (4) models shocks to the demand for gold as determined by domestic shocks to borrower riskiness (δ and θ), which raise the relative value of gold, and by other exogenous domestic and international demand and supply shocks (π^*). The level of nominal interest rates is included to capture the potential relationship between interest rate and price-level residuals, according to the Barsky-Summers [1988] model of the Gibson Paradox.[19]

Equation (5) gives a prominent role to cost-of-credit shocks in explaining output fluctuations. Our multiple-markets approach justifies the inclusion of several proxies for the cost of credit, including those that influence or reflect changes in borrowers' net worth (π and θ), interest rates (i and δ), and bank credit rationing (λ).

Equation (6) assumes that monthly failure shocks are exogenous, except for the influence of shocks to the level of interest rates during the month. Other within-month shocks are assumed to have negligible effects on business failures. That is, changes in "creditworthiness" are likely to have a delayed impact on bankruptcy.

Measures of predictive statistical significance, coefficient estimates for the simultaneous-equations model, and measures of the importance of variables in accounting for long-run forecast variance are reported in Tables I and II.

C. Results

As reported in Table I, we find that inflation predicts output growth and the risk premium significantly. Output growth is also predicted by other credit-market indicators—the commercial paper rate, the real flow of loans, and the percentage change in liabilities

19. In the Barsky-Summers model an increase in the interest rate raises the equilibrium marginal service flow from gold. Under fixed exchange rates, the price level must rise to equate the lower level of demand to the outstanding real stock of gold.

of business failures. The percentage change in the liabilities of business failures is predicted by the real change in loans, the commercial paper rate, and the interest differential.

Estimated coefficients and variance decompositions for the structural VAR model appear in Table II. With the exception of the coefficients on the risk premium in the output and price equations (d_2 and e_3), coefficients for contemporaneous shocks are of the predicted signs, and some are estimated precisely. As Sims [1986, p. 12] notes, however, the method we use for constructing standard errors need not be very accurate since it is based on an approximate second-derivative matrix. The best "tests" of the model's specification, Sims argues, are the impulse responses of the orthogonalized shocks. For example, if, as we assume, λ^* shocks reflect supply shocks to loans rather than demand shocks, impulses to λ^* should raise output and lower interest rates. If λ^* reflected shocks to loan demand rather than supply, its impulses would raise both output and interest rates. Thus, the combination of responses to each shock provides more convincing evidence of functional identification than the contemporaneous coefficient estimates.

Impulse responses and forecast variance decompositions confirm our functional identification and demonstrate that links between credit availability and real activity are economically important, as well as statistically significant. Exogenous failure shocks reduce output and raise the low-risk interest rate. Loan-supply shocks increase output, reduce interest rates, and reduce failures. Interest rate shocks reduce output and increase failures. Inflation shocks increase output and reduce both failures and the interest differential.[20] Shocks to i^*, λ^*, π^*, and θ^* have permanent effects on the level of output. Output responses to i^* shocks are largest in the first three months, and output continues to decline through the first sixteen months. Loan-supply shocks have persistent positive effects on the level of output which reach their peak in the eleventh month. In contrast, failure and deflation shocks exert their negative influence on output growth in the first four months. This suggests that failure and deflation shocks are associated with relatively rapid and sharp reductions in credit supply.

Shocks to loan supply, inflation, the low-risk interest rate, and business failures explain 10.6, 8.9, 16.9, and 9.9 percent, respec-

20. The cumulative response of *nominal* liabilities of business failures is small, but because price shocks are permanent, *real* liabilities of failed businesses fall dramatically in response to positive price shocks.

tively, of the thirty-month forecast variance of output. The twelve-month forecast variance decomposition is essentially identical.

Our results support viewing credit supply disturbances, rather than nominal rigidities, as the channel through which financial shocks influence real activity. In standard models of the monetary transmission mechanism (including the IS-LM model, and the Lucas [1973] monetary-shock confusion model), disturbances to aggregate demand are first reflected in changes in output, and later in price level adjustment. Price and wage rigidity provide the explanation for this timing difference. Our impulse response functions, however, indicate rapid adjustment of prices to disturbances in the economy. Price adjustment to all shocks either precedes or is simultaneous with the response of output.

The main deviations from the predictions of our model occur in the relationships between the risk premium and other variables, contemporaneously and dynamically. In our model we assume that increases in the risk premium reflect reductions in the creditworthiness of risky borrowers (see also Bernanke [1983]). This interpretation is not consistent with the signs on the d_2 and e_3 coefficients, or with the positive response of the risk premium to loan-supply shocks in simulation. At the same time, orthogonalized risk disturbances (δ^*) have the predicted positive effects on failures, and the predicted negative (though small) effects on loans and output. A possible explanation for the departures from the predicted values of d_2 and e_3, and the seemingly perverse response of the interest differential to loan-supply shocks is that lower-grade commercial paper is not a price-only-clearing market. Thus, general reductions in credit supply would be reflected in relatively large increases in interest rates on higher quality paper; the same shocks might have a greater effect on the shadow price of funds in the lower quality market, but operate mainly through reductions in quantity rather than increases in the rate charged.

In summary, our results suggest the importance of constraints on the availability of credit for real activity. That these effects are both economically important and persistent emphasizes the need to examine more carefully the dynamics of market clearing across various credit markets. The banking panics occurring during our period might best be studied as extreme examples of the problems of providing credit under nominal debt contracts in a world of asymmetric information and flexible prices. Our approach is relevant for localized changes in aggregate supply due to small changes in credit quality and information, as well, so that we avoid any dependence on "panic" explanations.

IV. International Linkages

Our credit-supply-cum-debt-deflation approach may help to explain why comovements in output across countries appear strong over some periods even in the absence of frequent worldwide financial crises. During our sample period the responsiveness of gold flows and close short-run links in commodity and capital markets (see Officer [1986], Clark [1986], and Calomiris and Hubbard [1987a]) produced a strong common component in asset and commodity price movements. These, in turn, are reflected in the business cycle experiences of nations under the classical gold standard.[21] Moore and Zarnowitz [1986] find that from 1897 to the onset of World War I there is a remarkable correspondence in the periodicity and timing of cycles in the United States, Britain, France, and Germany.[22] In the previous twenty years, however, the United States deviates from the common pattern of the other countries with cycles occurring independently and much more frequently.

These autonomous U. S. cycles in the late nineteenth century coincide with similarly dramatic U. S. departures from international patterns in nominal interest rates. In Calomiris and Hubbard [1987a] we show that *dollar* interest rates sometimes rose sharply as the result of the currency risk inherent in the controversy over "free silver." The importance of silver risk in causing increased nominal interest rates has been stressed by Garber [1986] and Grilli [1985]. This silver risk caused ex post redistributions of wealth from debtors to creditors when the gold standard was maintained. It also promoted short-run commodity price deflation by encouraging speculative capital flight from the United States (see Friedman and Schwartz [1963]). Thus, both the early period of relative domestic autonomy, and the post-silver-crisis period's pattern of international output comovements are consistent with an emphasis on credit supply as a source and propagation mechanism of disturbance to output.

V. Conclusions and Implications

Modern theoretical and empirical research on U. S. business cycles has in general relied on models with limited ability to explain

21. Bordo [1985] presents evidence of international linkages during financial crises. While this evidence is consistent with the debt-deflation approach, our framework is more general since it allows for important linkages through prices and interest rates during nonpanic episodes as well.

22. Moore and Zarmowitz [1986, pp. 756–57] provides a graphical illustration of the independent timing of U. S. business cycles prior to 1900.

cyclical fluctuations when prices are flexible. In particular, the existence of pronounced swings in economic activity during the period between the Civil War and World War I, a period in which prices exhibit little rigidity, does not fit well with these approaches.

In contrast to many recent conclusions about links between price rigidity and the adjustment of output to demand and supply shocks, we discuss channels through which such flexibility can be destabilizing through market failures in credit markets. When asymmetric information between entrepreneurs and suppliers of external finance is important in some sectors, "imperfect information" credit markets of the sort described by Stiglitz and Weiss [1981] will coexist with "full information" Walrasian credit markets. The potential for deflation magnifies credit restrictions for information-intensive borrowers and projects, and deflationary shocks precipitate a constriction of the supply of credit to borrowers in information-intensive markets.

In Section III we test for aggregate real effects of disturbances to credit supply during a period of relatively flexible prices and elastic money supply. We find that shocks to credit availability (including price shocks) produce positive and persistent effects on output. Our results suggest the usefulness of a multidimensional approach to measuring the shadow price of credit, which allows for multiple credit markets and heterogeneous agents.

Although our emphasis is on a historical episode of price flexibility, we do not mean to imply that credit restrictions are unimportant for economic activity in a world with substantial price rigidity. First, under sticky prices, nominal monetary disturbances will affect the real supply of bank credit (see Bernanke [1986]). Second, in some sectors of the modern economy, price volatility still poses a substantial threat to borrower creditworthiness. One sector of the modern economy for which price shocks are particularly relevant is the farm sector. Agricultural prices (and hence farmland values, the principal asset of farmers) are relatively flexible. If the sort of market failures discussed in this paper have aggregate effects, a likely place for them to be observed is in a link between farm bank failures and credit rationing and farm incomes. Calomiris, Hubbard, and Stock [1986] find that disruptions in the supply of credit available from local intermediaries have been an important propagation mechanism of shocks from centralized commodity and asset markets. More broadly, to the extent that banking-system difficulties and loan restrictions have important real

effects, important implications for monetary and regulatory policy may follow.

DATA APPENDIX

In order to capture short-run intertemporal linkages among credit, deflation, and output, it is necessary to employ high-frequency data, but the shortage of comprehensive data on output and bank balance sheets requires the use of rough proxies. For output we use pig iron production; data are obtained from *Historical Statistics of the United States, 1789–1945*. We construct a single index of wholesale prices by splicing the Warren-Pearson index (for 1879–1890) and the Bureau of Labor Statistics index (for 1890–1909). In Calomiris and Hubbard [1987a] we discuss results using more disaggregated data.

We construct monthly loans and reserves data from the weekly reports of the *Commercial and Financial Chronicle* for banks in New York City, Philadelphia, and Boston. Though these series represent only part of the banking system, they are the only available monthly data of their kind of which we are aware.

End-of-month interest rates are used for 1894–1909: on (i) 60–90-day double-name choice commercial paper (analogous to Macaulay's [1938] measures); (ii) single-name, good commercial paper of 4–6 months maturity; and (iii) single-name prime commercial paper of 4–6 months maturity. These are taken from *Statistics for the United States, 1867–1909,* published by the National Monetary Commission in 1910.

Dun's monthly series on the liabilities of business failures is from *Base Book of Standard Statistical Bulletin,* January 1932. Annual data on the liabilities of business failures are compiled from quarterly and monthly data on Dun's series in *Historical Statistics.* Annual data on failed bank assets are from Bremer [1935] which include national and state bank failures. Annual real GNP is from Balke and Gordon [1989].

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