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The permanent effects of innovation on financial depth: Theory and US historical evidence from unobservable components models

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Abstract

This paper examines links between innovation in the US intermediating sector and financial deepening from 1872–1929. Technical progress is modeled in a credit-rationing framework with limited liability as an enhanced ability of intermediaries to monitor loan recipients. This allows an innovating lender to earn temporary rents by lowering loan rates and inducing firms with higher repayment prospects to apply. Rents persist until others adopt the improvement and competition for loanable funds raises the deposit rate. Subsequent deposits ensure that more funds are channeled to projects of higher average quality. The link between the loan–deposit spread and financial deepening implied by the model is then examined in an unobservable components framework. The finding that permanent reductions of 1% in the spread of New York banks are associated with increases in financial depth that range from 1.7% to nearly 4% is consistent with a role for efficiency improvements in the rapid financial deepening that characterized the pre-1930 US economy. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

The 1872–1929 period in the US was one of substantial growth for both the financial and real sectors, with annual per capita growth averaging 4.4% for real intermediary assets and 2% for real output. It was also a period during which financial technologies improved drastically as long-distance communications became faster and more reliable, transportation networks reached completion, and capital markets unified. Gurley and Shaw (1955), Goldsmith (1969), McKinnon (1973) and Shaw (1973), in their studies of the US and other countries, presented evidence of positive correlation between the performances of the financial and real sectors and motivated a discussion of possible mechanisms through which financial technologies could affect macroeconomic outcomes. In particular, they find a relationship between financial deepening, or the relative size of the intermediating sector with respect to nominal income, and the growth rates of real output and investment. More recently, King and Levine (1993a) show the robustness of these findings using postwar data for a cross-section of 80 countries, and theoretical work (e.g., Bencivenga and Smith, 1991; Greenwood and Jovanovic, 1990; King and Levine, 1993b; Sussman, 1993) has supplied important foundations for some of the traditional causal arguments.

This paper recognizes the potential role of financial deepening in the rapid growth of real production in the US over the 1872–1929 period, yet focuses on the long-run sources of this deepening. It presents an example that includes a role for innovation in the interest rate setting decisions of competitive intermediaries using the credit-rationing framework first introduced by Stiglitz and Weiss (1981), and shows that an enhanced ability to monitor the activities of loan recipients can allow an intermediary in the presence of adverse selection and a risk-return tradeoff to earn temporary rents by lowering the interest rate on loans. Subsequent adoption of the improved technology by other lenders and Bertrand competition for loanable funds then raises the interest rate on deposits and encourages additional flows to the intermediating sector. While the empirical analysis does not provide explicit evidence that innovations within individual intermediaries diffused to the financial sector generally and had growth effects, it does link proxies for innovation with movements in the loan-deposit spread and does examine the implication that permanent reductions in the spread, which the example suggests can result from a more efficient intermediating sector, should be related to increases in financial depth.

The historical literature has long been concerned with interest rates and spreads. Studies by Sylla (1969) and James (1976) focus on the role of entry barriers and increased competitive pressures among postbellum intermediaries in narrowing regional interest rate differentials, while earlier work by Davis (1965) proposed that the proliferation of commercial paper was a key ingredient in the formation of a national short-term capital market. While these studies offer convincing arguments for innovation and changes in market power as determinants of reduced regional differences, they do not address possible causes for reductions in loan rates and loan–deposit spreads that appear over the 1872–1914 period among New York City national banks. These banks, which then served as the key reserve-holding institutions, engaged in price competition for loans and deposits throughout the postbellum period; thus, increased competition cannot explain downward movements in New York City spreads prior to 1914, and cannot account for their general downward trend after the establishment of the Federal Reserve. This paper suggests that permanent reductions in the spread may be largely attributable to technical improvements within a New York banking sector that faced informational asymmetries between themselves and their end-borrowers that were not unlike those presented in the example, though its assumptions are somewhat stronger than the informational conditions in credit markets at that time. Nevertheless, the example reinforces the notion of reduced loan rates as a competitive outcome that can result from increases in financial efficiency.

The hypothesis that permanent reductions in the loan-deposit spread offered by New York City national banks led to increases in financial depth is then examined empirically with a state-space specification in which transitory and permanent components are extracted from both the loan-deposit spread and broad measures of financial depth. The permanent components of the resulting variable pairs are modeled as independent random walks, with innovations in the permanent component of the spread exerting an influence on each observed measure of financial depth that cannot be attributed to its own permanent component. The maximum likelihood estimates from the unobservable components models, generated via the Kalman filter, indicate that one percentage point reductions in the permanent component of the loan-deposit spread are related to statistically significant increases of as much as 3.8 percent in the ratios of intermediary assets to GNP and reductions of as much as 6.4 percent in the ratios of bank capital to assets. The leading role for the spread implied by the model is further supported by an alternate specification in which the permanent component of financial depth fails to influence the spread. The findings are consistent with a distinct role for permanent spread reductions in the rapid financial deepening that characterized the pre-1930 US economy.

The paper is organized as follows. Section 2 describes the course of technical innovation in US banking from 1872 to 1929. Section 3 outlines a mechanism through which efficiency improvements can narrow interest rate spreads and increase the volume of intermediary activity. Section 4 describes the interest rates and measures of financial depth that are used in the analysis, lists the published data sources, and examines plots of the resulting series. Section 5 describes a state-space representation that captures the salient features of the theoretical mechanism. Section 6 tests the validity of the non-stationarity assumptions implied by the model, presents and evaluates maximum likelihood estimates of the key parameters, and evaluates the empirical support for possible determinants of the loan–deposit spread. Section 7 concludes.

2. The course of US banking innovation, 1872–1929

The role of innovation in reducing loan-deposit spreads and promoting financial deepening is often overshadowed in historical accounts of banking development by the importance of both the regional integration of capital markets (e.g., Davis, 1965) and the ineffectiveness of legislation aimed at ensuring widespread participation in the National Banking System (e.g., White, 1983). Nonetheless, the 1872–1929 period saw both improvements in the ability of banks to manage loanable funds and a rapid expansion of deposits.[1] Although the rapid spread of banks across interior regions relieved excess demand for deposit services and may partially explain the expansion, increased public confidence in the banking system prompted by a growing emphasis on professionalism among late nineteenth century bankers also combined with shifts in capital structure, portfolio choice and methods of information handling to make innovative banks increasingly safe and profitable outlets for personal and corporate savings.

In 1872, when this study begins, insider loans were still viewed as effective means of reducing informational frictions between lenders and borrowers (Lamoreaux, 1994). In fact, at this time the National City Bank (the forerunner of the modern day Citibank) was principally a vehicle for financing the business empire of its president, Moses Taylor. Conservatism was the cornerstone of banking policy, with key New York banks such as the First National, National City and Chemical operating with low leverage and reserves well above legal requirements while emphasizing deposit safety and 'ready credit' for established businesses through both commercial loans and the discount of two-name paper (Grant, 1992). By the 1880s, however, recognition of the profits that could be obtained by using the increasing deposit base more efficiently sparked innovations that resulted in more comprehensive approaches to overcoming informational asymmetries and attracting funds.

The growth of correspondent banking was a particularly important innovation. As Sylla (1969) argues, the movement of excess balances from country

[1] The average annual rates of growth for the combined deposits of national and non-national banks over 1872–1929 were 6.17% nominally and 5.35% in real terms (Bureau of the Census, 1973). The respective figures for national banks in New York City were 5.47% and 4.63% (US Comptroller of the Currency, various issues). The most rapid growth occurred from 1895 to 1904.

banks to their New York correspondents for investment in screened, monitored and easily liquidated call loans facilitated a transfer of funds from the short-term to the long-term capital market that fueled the steady course of US industrialization. Willingness of a city bank to discount in times of financial stringency for correspondents was especially crucial for obtaining interbank deposits, and George Baker of the First National Bank was the among first to take such risks.[2] As a result, First National rose from sixth among New York banks in 1870 with $4 million in interbank deposits to second by 1880 with $13.7 million and first by 1890 with $18.8 million (Myers, 1931) (pp. 245-6). Overall, call loans in New York banks grew from $56 million in 1875 to nearly $400 million by 1905, with their share in total loans rising from one-third in the 1870s to one-half over 1880–1900 before falling back to one-third by 1913 (Myers, 1931) (p. 272). While the correspondent system has been criticized (Sprague, 1910) for concentrating balances in New York and encouraging speculation in corporate equities, the call market actually generated considerable funding for interior businesses and does not appear to have swelled appreciably prior to downturns over the National Banking period.

New York banks also turned to the commercial paper market with increasing frequency to make investments for themselves and their less-informed correspondents. Much of this shift was due to single-name paper, which grew in popularity as screening improved and the impersonal nature of the market made banks less hesitant to liquidate paper upon maturity.[3] While a market for commercial paper existed in New York as early as 1880, it lost ground to call loans over the 1895–1904 period and did not regain its position as the largest outlet for short-term funds until 1910 (Myers, 1931) (p. 326). By then, commercial paper was already responsible for marked increases in the diversification of bank portfolios that had reduced the vulnerability of assets to distress liquidation in the face of sectoral shocks.

Credit departments became more common in national banks around the turn of the century, although the first was established in the 1880s by the Importers' and Traders' National Bank of New York as it expanded to become the largest holder of interbank deposits. These departments advised country correspondents about direct investments in commercial paper, and soon established more objective means of evaluating the condition of recipients for their growing

[2] Grant (1992) describes how First National helped the Rochester Savings Bank to avert a crisis in 1877 with a loan of $1.7 million based on the bank's holdings of $2 million in government and other 'good' bonds. The loan was repaid within days as deposits returned.

[3] Myers (1931) notes that while holdings of two-name commercial paper by national banks in New York City rose slowly from $95 million in 1877 to $185 million by 1914, holdings of single name paper steadily rose from $18 million to nearly $200 million over the same period.

volume of available funds. By 1894, borrowers were in most cases required to provide a statement of condition with their loan applications. Since commercial loans were often renewed, loan monitoring and the establishment of long-term customer relationships became particularly important for anticipating financial difficulties and improving recovery rates through planned liquidations and restructurings. This need was codified in 1910 when New York bank examiners established a credit bureau to ensure that single borrowers were not overextended. A national credit bureau was founded shortly thereafter.

The increases in the breadth and quality of loan portfolios were accompanied by a shift of balances in New York banks from excess primary reserves to a deeper set of liquid secondary reserves. Banks countered the additional risk by increasing their real capital levels, which may have allayed depositor fears despite overall increases in leverage. In fact, real capital levels grew by an annual average of more than 2% in New York City from 1872–1929, while the sum of capital and surplus grew by 3% (US Comptroller of the Currency, various issues). Using the latter measure, ratios of capital to assets actually rose over the 1890s and again from 1905 to 1913, which correspond to subperiods of active growth in call loans and commercial paper respectively.[4]

Although the New York Clearinghouse was established in 1853, provisions for reducing the risks associated with clearing for non-members (such as trust companies and most state banks) increased activity enormously after 1898 when annual clearances rose from $39 billion to over $57 billion in a single year (US Comptroller of the Currency, 1930) (p. 759). The expanded use of clearing facilities reduced balances in the process of collection and allowed banks to make more productive use of their funds. With the advent of the Federal Reserve System and legislative pressure for par clearances came a reduction in circuitous check routings that further improved the efficiency of the settlement system and lowered costs for clearinghouse members.

Deposit rates also began a marked rise early in the twentieth century. Although half of New York banks already paid interest on interbank deposits in 1886 and nearly all clearinghouse members had adopted the practice by 1891, trust companies with lower reserve requirements began to compete effectively for deposits by 1900. The growth of the trust companies, another key innovation of the 1890s (see Neal, 1971), forced commercial banks to innovate similarly and

[4] The largest New York banks recognized the need to signal the safety of depositor balances through increases in capitalization as they expanded their underwriting and foreign investment operations. National City Bank, however, under the direction of James Stillman, led this shift in financial structure by increasing its ratio of legal capital to assets from 5% in 1899 to over 20% by 1903 as excess reserves continued to fall. An eight-fold increase in corporate deposits over the decade ending in 1905 accompanied this innovation, reaching $142 million, while other national banks only tripled their corporate deposits over the same period (Cleveland and Huertas, 1985) (pp. 41–50).

surely contributed to the narrowing of loan-deposit spreads. By 1911, only the Chemical Bank had resisted paying interest on deposit accounts. The role of trust companies in expanding activities to include investment banking and the purchase of corporate bonds and equities also influenced the Federal Reserve Act of 1913 and its later amendments, which made it possible for national banks to widen profit opportunities by conducting foreign operations and administering trusts.[5]

Thus, despite its common characterization as a time of inefficiency and excessive regulation (see, for example, Grant, 1992), the 1872–1929 period saw the adoption of many important innovations by a US financial sector that was experiencing its most vigorous growth spurt. The next section builds upon existing theoretical perspectives to describe a mechanism through which innovation might explain a significant part of this transformation.

3. An illustrative example

The theoretical literature has identified several important ways in which more efficient intermediation can affect macroeconomic outcomes. King and Levine (1993b), for example, construct an endogenous growth model in which intermediaries play key roles in evaluating and sorting potential borrowers. The funding of projects with greater probabilities for success reduces the cost of enhancing productivity and leads to accelerated economic growth. In addition, a number of 'costly state verification' (CSV) frameworks focus on the ability of intermediaries to monitor the activities of loan recipients. These models suggest that delegation of the monitoring function from individuals to specialized intermediaries can reduce costs and free additional resources for productive use (Townsend, 1979; Gale and Hellwig, 1985; Williamson, 1986), and can encourage portfolio diversification and a reduction in idiosyncratic risk (Diamond, 1984).

The efficiency enhancement considered in the example that follows is consistent with CSV frameworks, and takes the form of reduced cost in verifying unfavorable project outcomes. It could also be viewed as an enhanced ability to liquidate the collateral of defaulting firms. Such improvements are shown to increase the size of the intermediating sector through reductions in the loan-deposit spread. While the example does not link the predicted increases in financial depth to long-run growth, as in King and Levine (1993a,b), its narrower focus highlights a potential cause of financial deepening, which is a key source of growth in their model.

[5] The fact that 29% of all national banks had received fiduciary powers by 1927 (Federal Reserve Board, 1928) (p. 35) underscores the importance of this legislation.

More specifically, financial intermediaries that observe the distribution of project success probabilities in the economy yet lack information about the repayment prospects of individual borrowers can use interest rates to influence the overall quality of loan applicants. If risky projects earn higher returns when successful than projects with low risk and the liability of defaulting recipients is fixed at an amount that all borrowers can offer as collateral, the safety of the applicant pool falls as the loan rate rises. This follows because potential borrowers with low return projects that are likely to repay at the contracted rate are driven from the loan market as interest payments become excessive, while those with riskier projects and the same liability earn greater returns when successful and require a much higher interest rate to withdraw their applications.

Under these conditions and not unreasonable assumptions about the supply of deposits, Stiglitz and Weiss (1981) show that competitive equilibrium may involve a non-Walrasian loan rate and an excess demand for credit. While this lower loan rate would maximize profits for intermediaries with a fixed deposit rate, competition for loanable funds raises the deposit rate until a zero-profit equilibrium obtains.[6] Since borrowers are observationally equivalent under this scheme, lenders choose actual recipients randomly from among the applicants until all loanable funds are distributed. The current analysis extends this framework to show that a more efficient intermediary can earn short-term rents by lowering its loan rate and forcing others to match the new rate (presumably by adopting the efficiency improvement) or exit. With a lower loan rate throughout the intermediating sector, the zero-profit condition implies a higher deposit rate, a larger volume of loanable funds, and ultimately more earning assets.

3.1. Borrowers

The model economy includes a continuum of risk-neutral borrowers indexed on the [0,1] interval by the success probability of a potential project that requires external funding. If borrowers know their position on the continuum and can use loans only to fund their own projects, expected output for a typical loan recipient is

$$E[Y_i \mid loan] = AK_i + p_i z_i L_i, \tag{1}$$

[6] The model assumes restrictions on entry. For a given interest rate on deposits, the maximization solution for each lender yields a rationing equilibrium that is invariant to the number of lenders and may yield rents (which, by assumption, cannot be eliminated by entry). Nevertheless, Bertrand competition among lenders for deposits causes a narrowing of spreads and the elimination of rents.

where A is the expectation of the current productivity shock (which is revealed after loans are distributed), K_i is the capital stock available to borrower i, L_i is the loan size, p_i is the success probability of the borrower's project, and z_i is the productivity of given loan upon project success. Loan size is proportional to the product of available capital and the expected productivity shock (AK_i/L_i equals a constant ϕ for all borrowers). If the lender holds a claim on output (AK_i) from unsuccessful projects, the expectation of retained output for a loan recipient is

$$E[Y_i^*|loan] = p_i[AK_i + (z_i - (1 + r))L_i], \tag{2}$$

where r is the real interest rate on loans. A borrower who chooses not to seek a loan or is rejected due to a shortage of loanable funds can expect to retain

$$E[Y_i^*|no\ loan] = AK_i. \tag{3}$$

A risk-neutral borrower submits an application when a loan implies a higher expectation of retained output than that associated with self-finance. A risk–return tradeoff enters the example through an assumption that the expected return on a loan is identical for all borrowers, which implies that

$$R = p_i z_i \quad \forall i. \tag{4}$$

The economywide return on financed projects (R) is an indicator of overall investment prospects in the current period. Using Eq. (4) to eliminate z_i from Eq. (2) and differentiating with respect to p_i yields

$$\frac{\partial(Y_i^*|loan)}{\partial p_i} = AK_i - (1 + r)L_i. \tag{5}$$

This expression indicates that the expectation of retained output increases with the probability of project success only when the borrower can be expected to repay the loan with interest regardless of project outcome. Since the ratio of the capital stock to the loan size (ϕ) is assumed constant, this would imply an economy with no possibility for loan default. Given that this is unlikely, the analysis considers the more interesting case in which the output surrendered to the lender upon project failure has lower value to the firm than the loan repayment at the contracted interest rate. Thus, AK_i is the binding liability limit for all firms. Given that $(1 + r)L_i$ exceeds the collateral requirement AK_i, firms with the lowest success probabilities satisfy the $(Y_i^*|loan) \geq (Y_i^*|no\ loan)$ condition and apply for loans. Firms with increasingly greater success prospects (and thus higher expected repayments to the lender) also apply until this condition holds with equality. Firms with success probabilities above this threshold are priced out of the loan market and rely on self-finance. The success probability of a firm (j) that is indifferent to borrowing is determined from Eqs. (2)–(4) by solving for p_j:

$$j(r) = p_j = \frac{R - \phi}{1 + r - \phi}, \tag{6}$$

where the notation $j(r)$ emphasizes the dependence of the success probability of the marginal project on the loan interest rate. If the contracted loan repayment exceeds the collateral requirement, the denominator of Eq. (6) is positive. The role of $j(r)$ as a probability then requires that

$$1 + r \geq R > \phi. \tag{7}$$

These conditions ensure that the applicant pool contracts as the loan rate rises ($\delta j(r)/\delta r < 0$).

3.2. Lenders

Intermediaries that observe the distribution of project success but lack information about the repayment prospects of individual firms set a loan rate that induces an applicant pool of optimal size. A monitoring cost for lenders that is directly proportional to the loan size enters the model when a borrower defaults and further influences rate setting decisions. Under these conditions, the expected profits of a competitive lender from granting a loan to borrower i are

$$E[\pi_i] = \int_0^{j(r)} [p(1 + r)L_i + (1 - p)bAK_i - (1 + \gamma_f)L_i] f(p)\, \mathrm{d}p, \tag{8}$$

where γ_f is a predetermined interest rate paid to depositors, b is the fraction of market value that the lender effectively obtains for liquidated output after monitoring costs in the event of default, p is the probability of project success, and f is the density function for p. Total expected profit for a lender at γ_f is directly proportional to the sum of Eq. (8) for all of its loan applicants:

$$E[\pi] = \left[\int_0^{j(r)} [p(1 + r - b\phi) - (1 + \gamma_f - b\phi)] f(p)\, \mathrm{d}p\right] \sum_i L, \tag{9}$$

where ϕ is the AK_i/L_i ratio.

3.3. Equilibrium

An extrema of the profit function in Eq. (9) must satisfy the first order condition

$$\frac{\partial E[\pi]}{\partial r} = \left\{[j(r)(1 + r - b\phi) - (1 + \gamma_f - b\phi)] f(j(r)) \frac{\partial j(r)}{\partial r}\right\} + \left\{j(r)F(j(r)) - \int_0^{j(r)} F(p)\, \mathrm{d}p\right\} = 0. \tag{10}$$

This condition balances marginal losses sustained by lenders when the loan interest rate rises and projects with the highest probabilities for success exit the applicant pool against larger repayments made by the remaining projects that succeed. The $[j(r)(1+r-b\theta)-(1+\gamma-b\theta)]$ term identifies the loss associated with a firm at the margin that withdraws a loan application, while the $f(j(r))$ and $\delta j(r)/\delta r$ terms represent the concentration of firms at the marginal probability and the sensitivity of this margin to interest rate changes respectively. The higher repayments over the remaining loan recipients which must offset marginal losses in the neighborhood of the equilibrium loan rate are related to the percentage of firms across the economy that receive loans and succeed. The second order condition requires that the increased repayments at the optimal interest rate fall at least as rapidly as the speed with which losses from the exit of high probability loan prospects are attenuated. The existence of an interior optimum depends critically on $F(p)$ and the model parameters. Corner solutions arise when the equilibrium conditions cannot be satisfied at any marginal success probability. The comparative statics results that follow examine the characteristics of equilibria that reflect interior solutions to the lender's problem.

Although lenders set the loan rate to maximize profits for a predetermined deposit rate, competition among intermediaries in the model drives long-run profits to zero via increases in the deposit rate. Setting the profit function in Eq. (9) equal to zero and fixing the loan rate at the value that satisfies Eq. (10) yields the zero-profit equilibrium condition for lenders:

$$E[\pi^B] = (1+r_f-b\phi)\left[j(r_f)F(j(r_f)) - \int_0^{j(r_f)} F(p)\,\mathrm{d}p\right] - (1+\gamma^*-b\phi)F(j(r_f)) = 0. \tag{11}$$

The deposit rate that satisfies this condition eliminates profits that existed at the initial deposit rate and completes the characterization of the competitive equilibrium with adverse selection.

3.4. *Comparative statics of increased efficiency in the financial sector*

This section examines the effects of varying levels of financial efficiency on equilibrium outcomes. As noted above, efficiency is modeled by the degree to which a lender can effectively retain the full market value of liquidated output upon borrower default (the size of the b parameter in Eq. (8)). Increases in b reflect an improved or less costly technology for monitoring loan recipients. Reduced costs directly ease the burden of loan default for an intermediary, while an improved technology may allow lenders to anticipate defaults sooner and use the additional time to locate an appropriate purchaser for recovered output.

The size of the overall effect of an efficiency increase on equilibrium interest rates and the volume of loan applications depends on $F(p)$ and its impact on the conflicting interest rate effects implied by the first order condition (10), but the direction is clear–equilibria with greater efficiency involve a lower loan rate and a larger applicant pool. Differentiating Eq. (10) with respect to b yields

$$\frac{\partial FOC}{\partial b} = -\phi f(j(r))\frac{j(r)}{(1+r-\phi)}\{1-j(r)\}. \tag{12}$$

The role of $j(r)$ as a valid probability and condition (7) together ensure that increases in financial efficiency lower the value of the equilibrium condition. Given that the second order condition requires a negative response of Eq. (10) to increases in r, a lower loan rate is needed in equilibrium. Since changes in b have no effect on the application decisions of firms, an accompanying increase in the applicant pool size can be inferred from Eq. (6).

The comparative statics follow directly from the restriction on the equilibrium loan rate imposed by the first order condition. This requires that losses over existing borrowers associated with a lower loan rate be compensated exactly by gains from new applicants. Since these losses are attributable to successful recipients only, they are unaffected by changes in b. Conversely, an increase in b raises the expected repayments of borrowers previously priced out of the loan market and causes marginal gains from new recipients to exceed losses over the original recipients. This imbalance implies a new equilibrium with a larger applicant pool.

3.5. Discussion

A graphical representation of the competitive equilibrium is shown in Fig. 1, which extends the illustration of Stiglitz and Weiss (1981) (p.397) to include the effects of improved and/or less-costly monitoring. The first quadrant includes typical aggregate demand (L^D) and supply (L_0^S) functions for loans. The supply function is constructed from the solid lender profit function in the second quadrant and the increasing supply function for deposits that appears in the third quadrant. The 45 degree line in the fourth quadrant assists in determining the height of L_0^S given the corresponding levels of lender profits and deposit supply. Note that the level of deposits increases with lender earnings. This implies that temporary profits in the competitive intermediating sector are eliminated through higher returns to depositors. An initial equilibrium, given by r_0^e, involves an excess demand for intermediated loans.

Greater monitoring efficiency yields the dashed lender profit function in the second quadrant, with the peak corresponding to higher temporary profits and a lower loan rate. With no change in the supply function for funds in the third quadrant, the increased returns to the lender imply higher returns to depositors

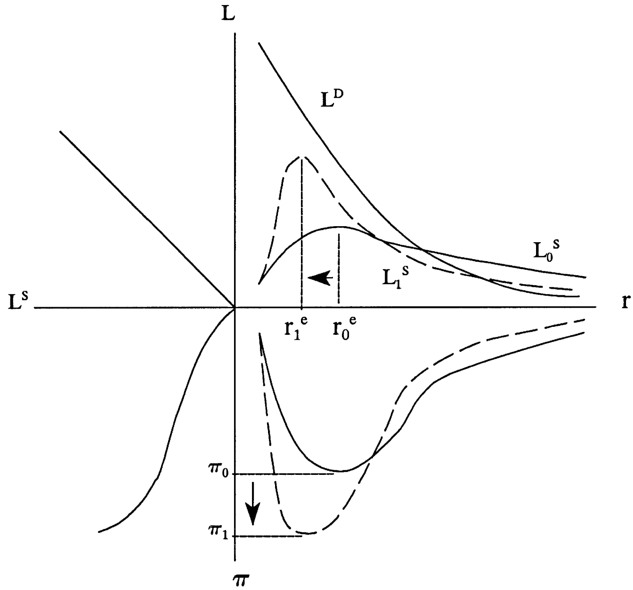

Fig. 1.

via the zero-profit condition and a more peaked supply of loans. The result is a new credit-rationing equilibrium with a lower loan rate, temporary rents for innovating lenders, and a higher interest rate on deposits.

The example specifies a mechanism through which technical progress in the intermediating sector leads to financial deepening through its influence on the interest rate setting decisions of lenders and the application decisions of loan seekers. To the extent that the efficiency improvements involve actions by the lender that are rarely reversed, the model also suggests that the resulting decreases in the spread between the interest rates on loans and deposits are permanent. The decrease in the spread induces an increase in the quality of loan applicants and a flow of funds to the intermediating sector. The remaining sections present evidence from the US financial sector over the 1872–1929 period that is consistent with this mechanism. A discussion of the data follows.

4. The data

4.1. Measures of financial depth

To examine empirically the role of permanent changes in the loan-deposit spread on the depth of intermediated finance in the US from 1872–1929, it is important to choose available price and financial quantity measures that can proxy for the theoretical constructs. Following the lead of Goldsmith (1969), a set of financial depth measures are derived from the asset side of intermediary balance sheets and are normalized by nominal GNP. The numerator quantities are the total assets of national banks (NATA), all banks (BANKA), and a composite that sums the assets of banks, life and property/casualty insurance companies, pension funds and investment companies (FIA). NATA/GNP is a reliable benchmark measure of patterns in the creation of bank credit. The broader BANKA/GNP measure includes both national and non-national bank assets, the latter consisting of State and private commercial banks and mutual savings banks. The FIA/GNP composite is perhaps the most useful of the measures in that it reflects the depth of intermediated finance generally, yet it is the least reliably measured. The flows of funds to the intermediating sector that the model relates to more efficient lending technology may also allow a given amount of bank equity to support a larger set of assets. For this reason, the capital to asset ratios of New York City banks (NYCCAP/ASSETS) and all national banks (NATCAP/ASSETS) are also included as measures of financial depth.

The GNP estimates are from Balke and Gordon (1986), and the assets of the banking sector are from the US Bureau of the Census, 1973, *Historical Statistics of the United States*: *Colonial Times to 1970*. The Census Bureau obtained its estimates prior to 1896 from annual issues of the *Report of the Comptroller of the Currency* (the 'Comptroller's report' hereafter), which include the assets of national and reporting non-national (State and private) banks. The data for non-national banks prior to 1896 are known to be incomplete due to under-reporting by some banks and the non-reporting of others. To account for these omissions, an adjustment based on work by Fand (1954) is used to correct the non-national totals. The adjusted series is then used to construct an additional measure of banking depth (BNKADJ/GNP). The FIA/GNP series uses the corrected totals for non-national banks. The assets of insurance companies, pension funds, and investment companies that augment bank assets in the FIA/GNP aggregate are from Goldsmith's *A Study of Saving in the United States* (1955) and the Census publication. The ratios of bank capital to total assets are derived from individual issues of the Comptroller's report.

While the ratios of national, non-national, and available intermediary assets to nominal output are imprecise measures of financial intensity when compared to other data items that have become available for the post-1945 period, they surely reflect the level of confidence placed in the banking sector by the general public. To the extent that this confidence grows as banks improve their abilities to allocate resources, long-run increases in these measures can be plausibly linked to greater financial efficiency and the provision of new services. Since assets were the primary output of intermediaries prior to the Great Depression, the selected measures also provide a reasonable approximation of the relative product of the financial and real sectors.

Fig. 2 displays the annual ratios that were constructed for 1872–1929 using call dates closest to June 30 for intermediary assets and annual averages for GNP. Persistent upward trends in the FIA/GNP, BNKADJ/GNP and BANKA/GNP measures are prominent, though the NATA/GNP measure also exhibits trending behavior. The growing gap between the BANKADJ/GNP and NATA/GNP series reflects rapid growth in the demand for deposit banking that led to the proliferation of State and private commercial banks from the 1880s through the turn of the century (see James, 1976), and rapid growth in savings institutions thereafter. Note that non-reporting and under-reporting banks prior to 1896 never account for more than 11% of the adjusted bank asset series, and that this difference had virtually vanished by 1892. Nevertheless, the adjusted series includes a small but noticeable reduction around 1893 that is missing from the unadjusted series.[7]

The time series patterns of the four measures are also broadly similar.[8] All series rise to a peak in 1875 and then decline gradually over the remainder of the decade. The rise may be the result of flattening production and an overextension of short-term railroad loans prior to the banking panic of September 1873. While severe, the panic was short-lived and avoided sharp loan contractions, yet had a lasting impact on orders, wages and incomes that could explain the behavior of the ratios until 1875. Output rose from 1876 with cautious reinvestment in railroads, yet deflation tempered the speed of the recovery and the financial depth measures did not reestablish their 1873 levels until 1879.

Resumption of specie payments in 1879 instilled confidence among investors and fueled a largely railroad-driven recovery that expanded financial assets by 1881. The recognition by investors of an inflated stock market may account for the decline in the ratio in 1882, but the subsequent depression induced declines in prices and output that increased the ratios despite a brief banking panic in 1884. The years 1885–1893, with the exception of mild recessions in 1887 and 1891, saw a steady rise in financial depth that outpaced a substantive expansion in real sector activity. The brief deviations of these ratios from their long-run trends around 1893, 1897, 1903 and 1907 reflect the pattern of output decline and financial friction that characterizes the contractionary episodes of these years. The need to finance the first World War placed a serious strain on the banking system, as the nation engaged in dissaving and rapid productive

[7] This difference is likely due to the impact of the 1893 crisis on small, non-reporting banks, many of which were located in rural areas where seasonal strains were most severe.

[8] The discussion of cyclical patterns draws heavily from the analyses of Fels (1959) and Friedman and Schwartz (1963).

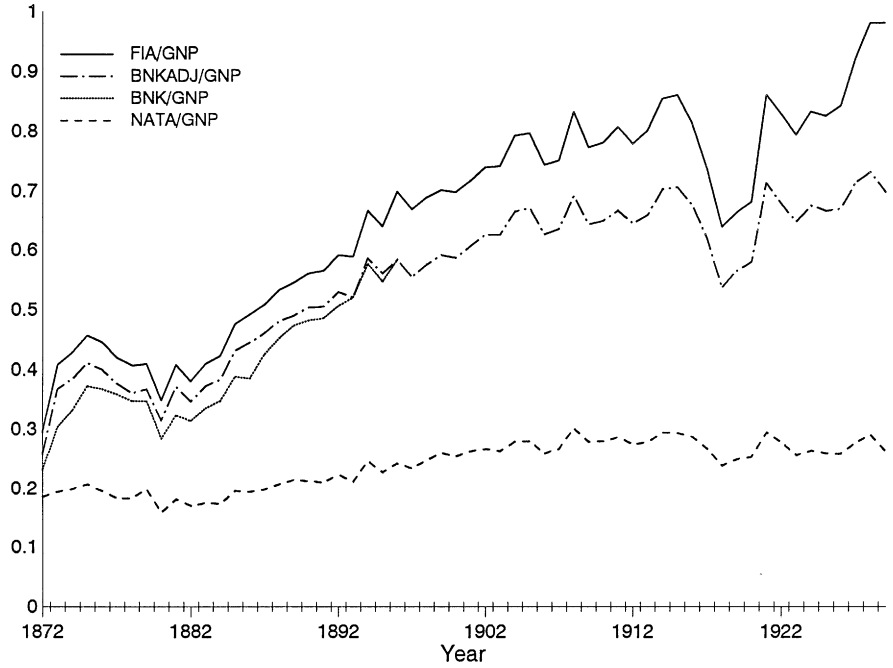

Fig. 2. US financial depth, 1872–1929.

expansion in an attempt to support its war efforts. Funds flowed back to the intermediating sector at the conclusion of hostilities until the downturn of 1921 saw banks again in difficulties. As documented in Friedman and Schwartz (1963), a general easing of credit conditions could well explain increases in the ratios from 1923–1929.

Fig. 3 plots the ratios of paid-in capital to total assets at call dates closest to June 30 for national banks in New York City, eastern reserve cities (including Albany, Baltimore, Buffalo, Philadelphia, Pittsburgh and Washington, D.C.), and all national banks. These ratios are also imprecise measures of financial depth in that they neglect the rapid growth of non-national deposit banks after 1880 that arose from reserve and capital requirements that were less stringent than those imposed upon national banks. Nevertheless, national banks remained the most important depository institutions throughout the sample period and fluctuations in their capital to asset ratios might be expected to reflect tendencies in more inclusive (yet unavailable) aggregates.

Capital requirements under the National Bank Act of 1863 were based on location, with a $50,000 minimum for national banks in communities with populations of less than 3,000. Since banks were prohibited from raising funds

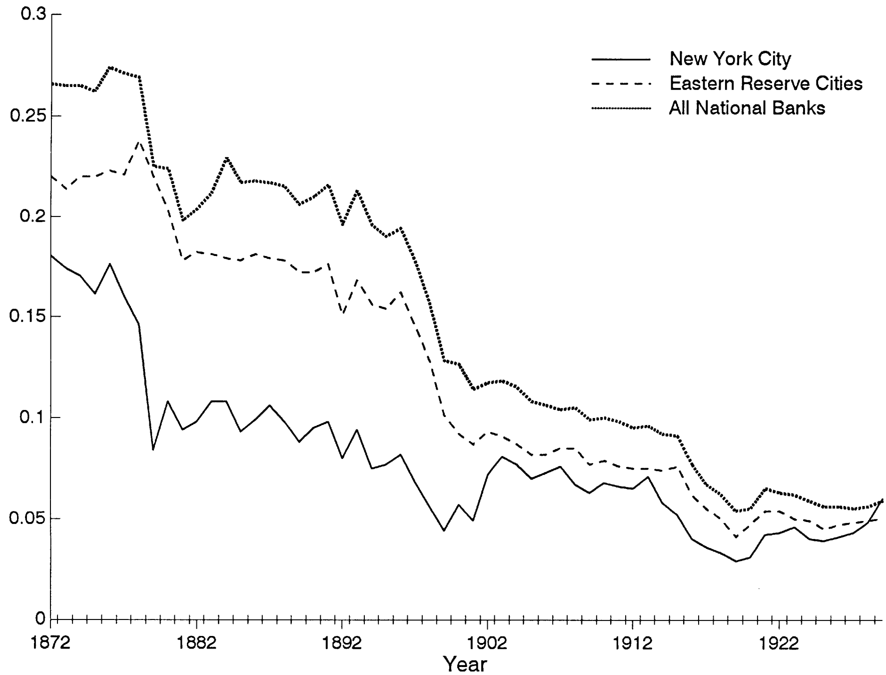

Fig. 3. Ratios of capital to assets for national banks, 1872–1929.

that were not subject to reserve requirements in excess of their paid-in capital, the requirements placed a limit on assets that could be supported by non-deposit sources. In addition, the original act required banks to hold one-third of their paid-in capital and no less than $30,000 in US bonds. These requirements presented an entry barrier for smaller prospective national banks that was raised in 1874 and subsequently lowered in 1882 by amendments to the legislation.[9] Since paid-in capital could not be withdrawn, however, for most banks the changes affected only the disposition of capital and not its total amount. The Gold Standard Act of 1900 lowered minimum capital to $25,000 in the smallest

[9] In 1874, the minimum amount of capital to be held in US bonds was raised to $50,000. Since US bonds earned interest and could be used to support note issue, the change tended to affect smaller banks that needed a large proportion of their capital to meet the bond requirement. In 1882, banks with less than $150,000 in equity were permitted to hold only one-fourth in US bonds. While a slowdown in the growth of the number of national banks in 1874 and a brief spurt after 1882 are consistent with capital requirements as an entry barrier for smaller banks, the change in growth pattern also follows a banking panic in 1873 and a slow recovery in business activity over the remainder of the decade.

Table 1
Average decadal growth rates of real per capita quantities

	GNP (%)	FIA (%)	BNKADJ (%)
1872–1879	4.05	6.09	6.62
1880–1889	0.71	5.04	5.04
1890–1899	2.32	4.28	3.60
1900–1909	2.17	3.41	3.31
1910–1914	− 0.25	0.90	0.64
1915–1919	1.45	− 3.47	− 2.78
1920–1929	1.68	7.07	4.98

Source: Wachtel and Rousseau (1995).

communities, yet is not associated with sharper downward movement in the aggregate ratio. For these reasons, the downward trends can be attributed primarily to increases in deposit-supported assets. Aggregate annual real growth rates for national banks of 5.5% for deposits, 4% for assets, and 1.6% for paid-in capital over the sample period are consistent with this interpretation.

It is important to note that while the real per capita assets of intermediaries grew rapidly from 1872–1929 with only a brief contraction during the first World War, the real sector performed strongly as well. The average decadal rates presented in Table 1 indicate that per capita growth in real output was particularly high in the 1870s, the decades surrounding the turn of the century, and the 1920s. These decades match those of robust growth in real per capita intermediary assets. Wachtel and Rousseau (1995) and Rousseau and Wachtel (1998), in studies of timing relationships between financial depth and output growth for the Anglo-American countries over the same period, find that financial depth also Granger-causes per capita real output growth with little evidence of feedback from output to the financial ratios. Their result confirms the robustness of the postwar cross-sectional findings of King and Levine (1993a,b) to changes in sample period and econometric technique, and suggest that movements in financial depth were an important factor in US growth prior to the Great Depression. These studies highlight the importance of isolating factors that can encourage financial deepening.

4.2. A measure of the loan–deposit spread

Appropriate interest rate data were more challenging to collect than the financial quantities. With average business loan rates of national banks available only from 1919, measures for loan-deposit rate spreads were needed for earlier years. A set of proxies are available in Davis (1965), which presents ratios of net returns of national banks to earning assets by region from 1872–1914 that presumably exhibit fluctuations similar in pattern to actual loan-deposit spreads. Of course, these ratios include non-interest expense and earnings from sources other than business loans. The original source of these ratios, issues of the Comptroller's report, were used to extend Davis' series through 1919. Spreads for 1920–1929 are differences between the average rate charged for short-term commercial loans and demand security loans (from the Board of Governors of the Federal Reserve System's 1943 *Banking and Monetary Statistics*) and the regular deposit rate of the Bowery Bank of New York (from Homer and Sylla, 1996).

The strong downward trends in these 'spreads' for most regions reflect increased competition within the banking sector and growth in commercial paper purchases as a national capital market formed, and as such do not capture clearly the role of technical improvements described in the preceding model. The New York City national banks, however, were already quite competitive by the 1870s, so that movements in their net earnings ratios might reflect technical progress in the banking sector more sharply. As the New York banks were also central reserve city banks, movements in these spreads might also be related most consistently to changes in the size of the intermediating sector generally. For these reasons, the loan-deposit rate spreads used in the empirical analysis are those for New York banks.

Fig. 4 plots the annual proxies for the loan-deposit spread using returns and earning assets reported at call dates closest to June 30 prior to 1919 and annual averages thereafter. Series are included for national banks in New York City, eastern reserve cities and the country at large, with the latter derived by the author from individual Comptroller's reports using Davis' method. While the series differ in the degree of their downward trends, all exhibit sharp year-to-year fluctuations that roughly correspond to business cycle turning points. The net yields decline precipitously during the downturn of 1873–1876, rise during the subsequent recovery, and fall again during the depression of the early 1880s. They then climb through 1887 and remain relatively steady until 1893, when a sharp decrease accompanied another business contraction. Fluctuations in the net yields continued to accompany the banking crises of 1903 and 1907, while the strains on loanable funds associated with the rapid industrial expansion of the first World War led to their widening. The spreads fell consistently from 1921–1926, and then increased steadily through 1929.

4.3. Model implications for loan and deposit rates

The example presented in Section 3 implies that improvements in financial efficiency lead to permanent reductions in loan-deposit rate spreads, which can in turn be attributed to decreases in real loan rates and increases in real deposit rates. The sketchiness of loan and deposit rate data prior to 1919 and the erratic behavior of the price level from 1915–1922, however, render these implications

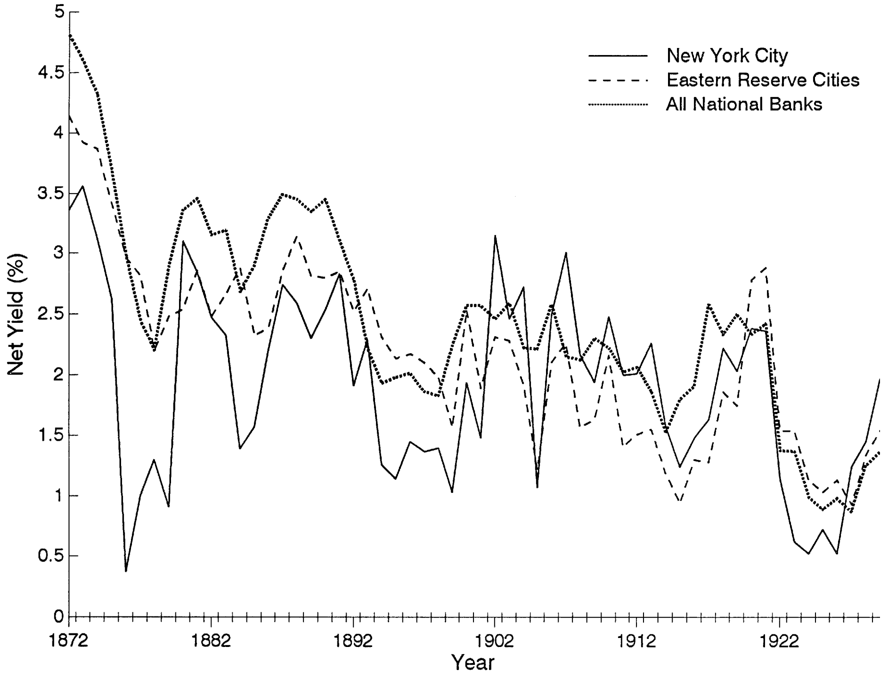

Fig. 4. Net yields of national banks, 1872–1929.

difficult to evaluate decisively. Fig. 5 presents proxies for the loan rate charged by national banks in New York City, eastern reserve cities, and the country at large. The series for New York and the eastern cities are ratios of gross returns to earning assets from Davis (1965) for 1888–1914 (note that gross earnings became available only after 1888) that have been extended from individual issues of the Comptroller's reports through 1919, and are average business loan rates from the Board of Governors of the Federal Reserve System (1943) thereafter. The series for national banks was derived from the Comptroller's reports using Davis' method.

The nominal gross yields exhibit a sharp downward trend from 1888 until the turn of the century, drift generally upward until 1918, and fall thereafter. While the trends are not uniformly downward, loan rates consistently fell during periods of less variable inflation (1888–1902 and 1922–1929), and rose during periods of higher and more variable inflation (1908–1920). Fig. 6 presents the ex-post real gross yields for the 1888–1914 period using the annual change in the implicit price deflator for gross national product from Balke and Gordon (1986). With the exception of a rapid and brief deflation in 1910, this graph indicates a clear downward trend in real loan rates prior to the first World War. The 1915–1929 period is omitted from the graph due to large and erratic swings in

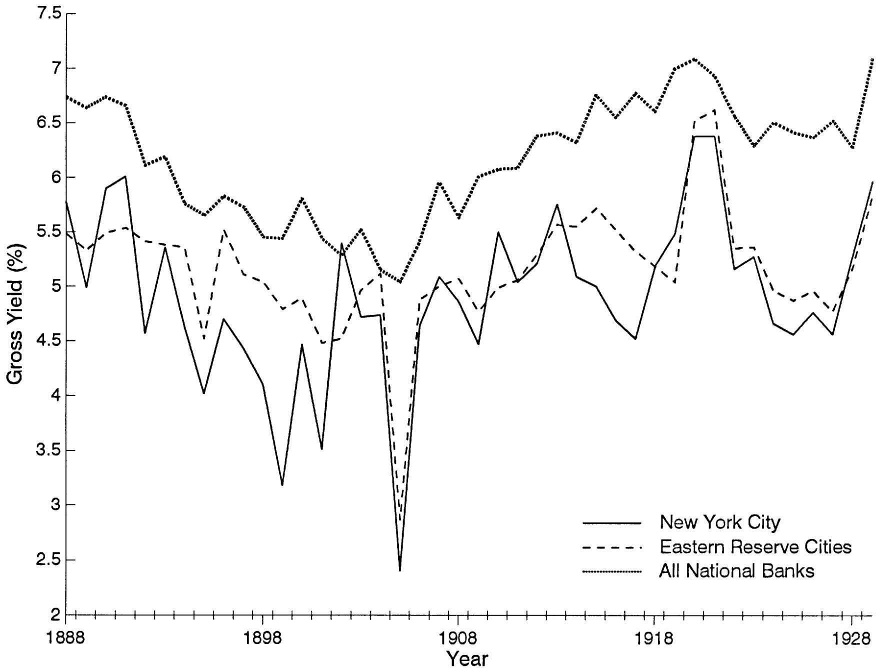

Fig. 5. Gross yields of national banks, 1888–1929.

the price level over the war years and early 1920s which make the equally variable ex-post rates unlikely to reflect accurately inflationary expectations of potential lenders and borrowers. Ex-post real rates were relatively steady after 1922.

Information on deposit rates is more sparse than that available for loan rates. Data from the 1870 Comptroller's report indicates an average deposit rate of only 1% for national banks. Cagan (1965) (p. 320) also suggests that higher commercial bank earnings and more intense competition for deposits in the decades before and after the turn of the century led to an increase in deposit rates after 1905. Indeed, the available deposit rate data for state and private commercial banks that operated in Kansas from 1897–1927 indicate substantial increases after 1900, with estimates of 0.71% in 1900, 0.94% in 1910, and 1.68% in 1920. While the differences between gross and net yields of national banks (as shown individually in Figs. 5 and 4 respectively) reflect both interest and non-interest expense, the differences trend slightly downward (but not as strongly as gross yields) prior to 1905 and are then consistently and strongly upward trending through 1929.

Overall, the available evidence on loan rates and deposit rates is consistent with the model implications, although lower loan rates were a more important

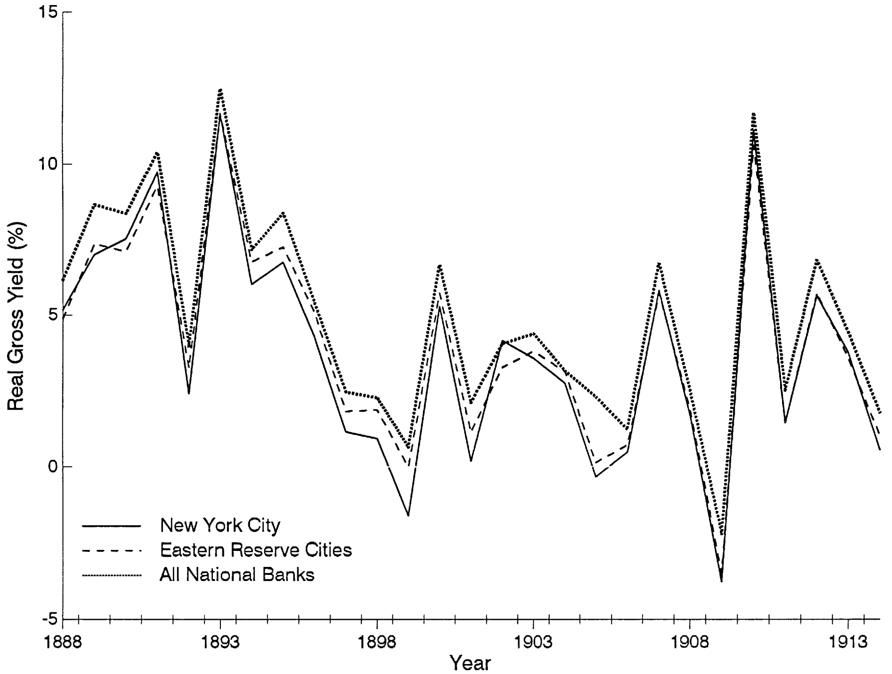

Fig. 6. Real gross yields of national banks, 1888–1914.

contributor to spread reductions prior to 1908 and increases in deposit rates seem to have influenced the spread more emphatically over the last twenty-five years of the sample.

5. Empirical overview

The example describes a mechanism through which efficiency improvements in the intermediating sector induce permanent reductions in the loan-deposit spread that encourage financial deepening. The data plots presented in Section 4 also make clear that short-term fluctuations in the ratios of intermediary assets to nominal output and the loan–deposit spread were strongly related to the business cycle. Since the model suggests that changes in the permanent component of the loan-deposit spread related to technical progress within the banking sector can have permanent effects on financial depth, the plots underscore the need to separate transitory fluctuations in the data associated with the business cycle from innovations in the stochastic trends of the series. For these reasons, the empirical specification considered next performs this decomposition and shows that the time path of financial depth is related significantly to two independent influences–its own stochastic trend and the permanent component of the loan-deposit spread.

These implications can be captured with a state-space specification in which both the spread and the depth of intermediated finance are driven by independent stochastic trends. Innovations in the permanent component of the spread are posited to influence the time path of financial depth. Such a process could take the form

$$y_{f,t} = \beta x_{s,t} + x_{f,t} + v_{f,t}, \qquad (13)$$

where $y_{f,t}$ is a measure of financial depth, $x_{f,t}$ is its permanent component, $x_{s,t}$ is the permanent component of the loan-deposit spread, and $v_{f,t}$ is white noise. The spread is not influenced by changes in the permanent component of financial depth and is modeled as

$$y_{s,t} = x_{s,t} + v_{s,t}, \qquad (14)$$

where $y_{s,t}$ is the observed spread between loan and deposit rates. The white noise errors $v_{f,t}$ and $v_{s,t}$ may be contemporaneously correlated, but are uncorrelated across time. Together, Eqs. (13) and (14) are the 'measurement' equations of the state-space model.

The permanent components of financial depth and the loan-deposit spread are modeled as independent random walks of the form

$$x_{f,t} = x_{f,t-1} + w_{f,t}, \qquad (15)$$

$$x_{s,t} = x_{s,t-1} + w_{s,t}, \qquad (16)$$

where $w_{f,t}$ and $w_{s,t}$ are whitenoise with $\mathrm{E}(w_t w'_{t\pm i}) = 0\ \forall i$ and $\mathrm{E}(w_{f,t} w'_{s,t}) = 0\ \forall t$. Eqs. (15) and (16) are the 'transition' equations, with $x_{f,t}$ and $x_{s,t}$ the time t realizations of the state vector.

Model identification requires that v_t and w_t be uncorrelated at all leads and lags. This implies that shocks to the permanent component of the loan-deposit spread have only those effects on financial deepening and the observed spread that are explicitly modeled in the measurement equations. Note that the validity of the model also depends on the independence of $x_{f,t}$ and $x_{s,t}$, and the non-stationarity of the observed data series. This implies that the observed series for the spread and financial depth are both integrated of order one, but are *not* cointegrated. Once the observed series are shown to be consistent these properties, the state-space representation given by Eqs. (13)–(16) can be estimated via the Kalman filter and the prediction error decomposition form of the likelihood function (see Harvey, 1989).

The Kalman filter technique relates the observations given in the measurement equations with estimates of their permanent components as specified in the transition equations. Maximum likelihood analysis involves the estimation of β, cov($v_{s,t}$, $v_{f,t}$), var($v_{s,t}$), var($v_{f,t}$), var($w_{s,t}$) and var($w_{f,t}$). The primary outputs of the filter are jointly-determined estimates of time paths for the state variables (x_s and x_f), which are obtained with a plausible initial guess of the parameter vector and diffuse choices for the time 0 state vector and its covariance matrix.[10]

The mechanism described in Section 3 suggests that efficiency improvements within the intermediating sector, which in the absence of technical regression are generally not reversed, can induce reductions in the loan-deposit spread. This implies a distinction between permanent components of the spread, which are plausibly driven by these improvements, and residual components that are driven by transitory shocks. Eq. (13) specifies a role for the permanent components of the spread in the process of financial depth that cannot be attributed to its own permanent component ($x_{f,t}$). Given that decompositions of the observations are required to examine these relationships, the ability of the Kalman filter to jointly determine all parameters of interest and thus allow for non-zero covariance in the error terms of the measurement equations renders it preferable in this application to alternative multiple-step schemes (e.g., Beveridge and Nelson, 1983) in which permanent components of the two data series are extracted separately. As the Kalman filter computes the log likelihood for each observation in the sample, it delivers optimal one-step ahead predictions of the state vector that utilize all information available about the system variables prior to time $t+1$. Thus, the forecast errors in the financial series (or deviations of the data from the best estimate of its non-stationary component) are driven by events that are not embedded in the past history of financial depth. The state-space model identifies permanent innovations in the spread as determinants of these deviations, and facilitates analysis of their statistical importance. A negative and significant estimate of β in Eq. (13) would provide support for the posited inverse relationship.

In practice, the validity of estimates from the state-space representation depends on the plausibility of the white noise assumption for the residuals in the measurement equations ($v_{f,t}$ and $v_{s,t}$). In the event that diagnostic tests find these residuals to differ significantly from white noise, the model must be re-estimated with a more structured specification for the error process. This issue and the results are discussed further below.

[10] Given the non-stationarity of the state variables in the model, diffuse priors can be approximated in practice by using the first observations in the sample as estimates of the time 0 state and setting their covariance to be an identity matrix with large diagonal elements.

Table 2
Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) statistics for US financial variables 1872–1929

	Levels		1st differences	
Financial variable	ADF	PP	ADF	PP
ln(FIA/GNP)	− 1.71	− 2.17	− 4.20*	− 8.68*
ln(BNKADJ/GNP)	− 1.44	− 2.08	− 4.42*	− 9.15*
ln(BANKA/GNP)	− 1.31	− 1.95	− 4.42*	− 8.48*
ln(NATA/GNP)	− 1.29	− 1.41	− 4.28*	− 11.15*
ln(NYCCAP/ASSETS)	− 2.90	− 2.55	− 4.12*	− 8.51*
ln(NATCAP/ASSETS)	− 2.11	− 2.58	− 4.12*	− 6.65*
$r_L - r_D$	− 3.39	− 4.69*	− 5.37*	− 9.72*

Notes: The ADF regressions include four lags of the dependent variable, constant and trend. The automatic bandwidth selection technique of Andrews and Monahan (1992) is used to determine appropriate lag length for computing the spectrum in the Phillips–Perron tests. An asterisk denotes rejection of the unit root hypothesis at the 5% level using critical values from Table 8.5.2 of Fuller (1976).

6. Results and discussion

6.1. Unit root tests

Table 2 presents a set of Augmented Dickey–Fuller (see Said and Dickey, 1984) and Phillips and Perron (1988) unit root tests.[11] Both tests fail to reject the null hypothesis of a unit root at the 5% level for all financial depth measures in log levels, and thus offer no indication that the non-stationarity assumptions embedded in the components models are unrealistic. The tests conflict, however, for the level of the loan-deposit spread. While this conflict is consistent with the belief that the spread may exhibit sluggish mean reversion (perhaps in response to excessive drift), the tendency for Phillips–Perron tests to over-reject the null in small samples for processes with large negative MA components (see Schwert, 1989) suggests that there is ample justification to proceed under the assumption that the spread contains a permanent component. All tests with the log difference of the financial quantities and first difference of the spread reject a unit root, which implies that the maximum order of integration for the data series under consideration is one.

[11] The choice of four lags in the Augmented Dickey–Fuller (ADF) tests exceeds that computed by the Akaike and Schwartz criteria for these variables, yet possible efficiency losses resulting from this choice appear preferable to the tendency for ADF tests to over-reject the null when these information criteria are employed (see Schwert, 1989).

6.2. Cointegration tests

Since the state-space representation requires independence of the permanent components of financial depth and the loan–deposit spread, it is appropriate to examine whether the observed data are consistent with this 'non-cointegration' assumption. Inferences are based on the approach described in Johansen (1991) and extended to models with time trends in Johansen (1992).

Table 3 presents Johansen's trace and maximum eigenvalue statistics (η_r and ζ_r) for combinations of the spread and each of the financial depth measures. Linear trends in the financial depth measures (see Fig. 2) suggest the inclusion of an intercept in the specifications. Model 1 includes this intercept unrestrictedly, while Model 2 also includes a linear time trend. For both models, the maximum eigenvalue tests fail to reject the r = 0 hypothesis at the 5% level for any of the variable pairs. The trace test rejects the null of no cointegration only for Model 1 in the systems with NATA/GNP and NYCCAP/ASSETS as financial depth measures. Since the time patterns of the data suggest that any cointegrating relationship is likely to be trend stationary, however, the failure of the tests for Model 2 to find evidence of cointegration in all cases is particularly supportive of the independent stochastic trends specification. The residuals from the Johansen regressions show no signs of serial correlation, and do not appear to deviate significantly from normality.

Table 3
Johansen cointegration tests for the US loan–deposit spread and measures of financial depth, 1872–1929

	Trace (η_r), $H_0: r = 0$		λ-max (ζ_r), $H_0: r = 0$		$H_0: r = 1$	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
ln(FIA/GNP)	14.16	19.63	13.09	14.59	1.07	5.04
ln(BNKADJ/GNP)	15.10	19.05	12.64	15.00	2.46	4.05
ln(BANKA/GNP)	14.45	17.60	11.93	14.60	2.51	2.99
ln(NATA/GNP)	15.68*	19.61	14.00	17.20	1.68	2.41
ln(NYCCAP/ASSETS)	15.72*	15.36	10.94	9.65	4.78*	5.71
ln(NATCAP/ASSETS)	12.47	17.43	12.40	11.18	0.07	6.24

Notes: Each system couples the loan–deposit spread with the measures of financial depth in the left column. The levels term enters each model at three lags, with the lag order determined by a series of nested likelihood ratio tests. The columns labelled $r = 0$ test a null hypothesis of no cointegration, while the $r = 1$ columns test a null hypothesis of a single cointegrating vector given rejection of $r = 0$. Model 1 includes an unrestricted intercept, while Model 2 includes an intercept and time trend. * denotes rejection of the null at the 5% level using critical values from Tables 1 and 2* (for Models 1 and 2 respectively) of Osterwald-Lenum (1992).

6.3. Estimation of unobservable components models

In practice, a representation of Eqs. (13)–(16) suitable for direct estimation must be consistent with observed data features and yield residuals in the measurement equations that approximate serially uncorrelated white noise. To this end, the trending nature of the financial depth series suggest the inclusion of a drift term in Eq. (15). Choosing an MA(1) in the measurement equation for the spread also placed adequate structure on the error process to yield white noise residuals in the estimated systems. This adjustment is appropriate in light of the unit root tests presented in Table 2, which suggest that the spread would (at the very least) have a sizable transitory component with cyclical features that might be captured parsimoniously by such a specification. With these adjustments, the transition equations for the estimated models become

$$x_{f,t} = x_{f,t-1} + d_f + w_{f,t}, \tag{17}$$

$$x_{s,t} = x_{s,t-1} + w_{s,t}, \tag{18}$$

where d_f is the deterministic drift. The measurement equations become

$$y_{f,t} = \beta x_{s,t} + x_{f,t} + v_{f,t}, \tag{19}$$

$$y_{s,t} = x_{s,t} + \theta v_{s,t-1} + v_{s,t}, \tag{20}$$

where θ is the moving average parameter for the error process.

The estimates of the β coefficient reported in Table 4 relate a 1% reduction in the permanent component of the loan-deposit rate spread with increases in financial depth of 1.7% for the narrow NATA/GNP measure, 2.8% for the measure with adjusted total bank assets, 3.8% for unadjusted bank assets, and 2.7% for the broadest FIA/GNP measure. While these coefficients are not quantitatively large, their precision (all are significant at the 2% level or less) suggests that permanent reductions in the spread have played a discernable and persistent role in the rapid financial deepening that occurred over the 1872–1929 period. The larger estimates for the broader aggregates (FIA/GNP, BANKA/GNP and BNKADJ/GNP) may reflect the extent to which these measures are more indicative of total activity in the intermediating sector. Reductions of 1% in the permanent component of the spread are also related to decreases in capital to asset ratios of 5.8% for New York City banks and 6.4% for national banks at large, with the β coefficients for both systems significant at the 1% level. The significance of the deterministic drift terms at the 10% level or less in the transition equations for all financial variables other than NYCCAP/ASSETS indicate that their inclusion was indeed necessary. The negative and significant estimates of the θ coefficient in all systems and the lack

Table 4
Maximum likelihood estimates for US components models, 1872–1929

Financial depth Measure (×100)	β (s.e.)	d_f (s.e.)	θ (s.e.)	DW fi/(spr)	Q(2) fi/(spr)	Q(14) fi/(spr)
ln(FIA/GNP)	−2.698	1.634	−0.425	1.88	0.368	0.671
	(1.231)	(0.749)	(0.115)	(2.13)	(0.829)	(0.867)
ln(BNKADJ/GNP)	−2.765	1.179	−0.434	1.90	0.553	0.653
	(1.283)	(0.652)	(0.121)	(2.16)	(0.759)	(0.853)
ln(BANKA/GNP)	−3.816	1.306	−0.442	1.75	0.409	0.712
	(1.070)	(0.702)	(0.134)	(2.25)	(0.578)	(0.839)
In(NATA/GNP)	−1.669	0.774	−0.507	1.74	0.394	0.242
	(0.719)	(0.532)	(0.129)	(1.94)	(0.313)	(0.394)
ln(NYCCAP/ASSETS)	5.781	−1.785	−0.469	1.99	0.912	0.440
	(2.079)	(2.011)	(0.023)	(2.39)	(0.129)	(0.644)
ln(NATCAP/ASSETS)	6.406	−2.869	−0.476	1.71	0.841	0.680
	(1.861)	(0.974)	(0.012)	(2.47)	(0.138)	(0.535)

Notes: The table presents maximum likelihood estimates of the system in Eqs. (17)–(20). The financial depth measure coupled with the loan–deposit spread in each system appears in the left column. The next three columns report estimates and standard errors for β, the drift term (d_f), and θ. The remaining columns report Durbin–Watson statistics and the significance levels of Q tests for serial correlation in the residuals of the measurement equations at lags of two years and fourteen years (approximately one-fourth of the sample size), with the tests for the spread equation (20) appearing in parentheses beneath those associated with the financial depth equation (19). The financial depth measures were multiplied by 100 to aid in obtaining convergence.

of serial correlation in the residuals of the measurement equations suggest that the more structured specifications of the error processes were also appropriate.

The results in Table 4 reflect an ability of the permanent component of the loan-deposit spread to improve one-step ahead forecasts of the financial depth measures, but do not preclude the possibility that the variables are jointly determined. For this reason, an alternate specification is examined in which the permanent component of financial depth can influence the observed spread. The transition equations are identical to Eqs. (17) and (18), but the measurement equations become

$$y_{f,t} = x_{f,t} + v_{f,t}, \tag{21}$$

$$y_{s,t} = \alpha x_{f,t} + x_{s,t} + \theta v_{s,t-1} + v_{s,t}, \tag{22}$$

where α measures the impact of a change in the permanent component of financial depth on the observed spread. The estimates for α presented in Table 5 are not significant for any of the systems, and there is no evidence of serial correlation in the residuals. This finding is consistent with a unidirectional

Table 5
Maximum likelihood estimates for alternative specification, 1872–1929

Financial depth Measure (× 100)	α (s.e.)	d_f (s.e.)	θ (s.e.)	DW fi/(spr)	Q(2) fi/(spr)	Q(14) fi/(spr)
ln(FIA/GNP)	− 0.006	1.591	− 0.399	2.03	0.411	0.487
	(0.005)	(0.772)	(0.047)	(2.03)	(0.327)	(0.837)
ln(BNKADJ/GNP)	− 0.003	1.128	− 0.392	2.02	0.557	0.472
	(0.015)	(0.658)	(0.048)	(2.06)	(0.384)	(0.855)
ln(BANKA/GNP)	− 0.005	1.269	− 0.388	1.99	0.567	0.678
	(0.012)	(0.713)	(0.066)	(2.01)	(0.349)	(0.836)
ln(NATA/GNP)	− 0.005	0.693	− 0.374	2.06	0.790	0.502
	(0.018)	(0.437)	(0.058)	(2.11)	(0.413)	(0.895)
In(NYCCAP/ASSETS)	0.001	− 1.450	− 0.308	2.00	0.446	0.375
	(0.007)	(1.960)	(0.133)	(1.87)	(0.377)	(0.812)
ln(NATCAP/ASSETS)	0.002	− 2.771	− 0.370	1.92	0.391	0.845
	(0.003)	(0.962)	(0.058)	(1.99)	(0.364)	(0.474)

Notes: The table presents maximum likelihood estimates of the system in Eqs. (17) and (18) and Eqs. (21) and (22). The financial depth measure coupled with the loan–deposit spread in each system appears in the left column. The next three columns report estimates and standard errors for α, the drift term (d_f), and θ. The remaining columns report Durbin–Watson statistics and the significance levels of Q tests for serial correlation in the residuals of the measurement equations at lags of two years and fourteen years (approximately one-fourth of the sample size), with the tests for the spread equation (22) appearing in parentheses beneath those associated with the financial depth equation (21).

leading role of the permanent component of the spread in financial deepening; it also suggests that the variables in Eq. (19) are not driven simultaneously by an omitted regressor.

6.4. Robustness

The findings reported in Section 6.3 are generally robust to changes in the starting and ending dates of the sample. For example, it might be sensible to check for robustness by removing 1872, 1873 and 1923–1929 from the sample, since these were the years during which the loan-deposit spread experienced its largest downward movements. In this case, unit root tests continue to be consistent with non-stationarity for all series in levels. The Johansen tests that allow a trend in the cointegration space (Model 2) remain unable to detect a cointegrating relationship among any spread-financial depth pairs, though marginal cointegrating relationships are detected for several pairs with the less appropriate unrestricted intercept specification (Model 1). The MLEs of the β coefficients for all systems given by Eqs. (17)–(20) are roughly the same, though the significance levels rise slightly. All remain significant, however, at the 10% level or less.

6.5. Explaining movements in the loan–deposit spread

The above findings link reductions in the loan-deposit spread to increases in financial depth but offer no direct evidence for the model implication that financial innovation was an important spread determinant. To shed light on the issue, this section uses available data from the Comptroller's reports to build proxies for some of the innovations described in Section 2 and examines their abilities to explain movements in the spread. The proxies reflect improvements in loan screening in addition to the CSV technologies explicitly addressed in the example, since better screening of potential borrowers also improves the effective applicant pool (King and Levine, 1993b) and under credit rationing may lead to lower loan rates. Alternative explanations for the spread that are not encompassed by the example are then considered.

Specifically, movements in the ratio of loans and private security holdings to total assets for national banks in New York City (NYCLS/ASSET) may reflect improvements in monitoring and screening insofar as they reduce losses and allow intermediaries to carry more profitable assets while maintaining a given level of portfolio risk. Since the expected returns on loans, equities and corporate bonds were higher than those on government securities (including US bonds to support circulation), improvements in liquidity, transaction clearing, and information collection and transfer could explain the path of observed portfolio shifts.[12] Secondly, increases in clearinghouse efficiency allowed banks to reduce float and minimize losses associated with confusion and the failure of non-member institutions, thereby freeing funds for placement in earning assets. As such, movements in the ratio of transactions at the New York clearinghouse to deposits in New York City national banks (NYCCLEAR/DEP) may also reflect technical innovation (see Neal, 1971). Finally, the model implies that innovative rents in a competitive intermediating sector should dissipate as an innovation diffuses and in turn should narrow the spread. One measure of rents that is available continuously is the ratio of change in surplus and undivided profits for New York banks to total assets (NYCPROF/ASSET). To the extent that the rents are a result of innovation, one might also expect this ratio to lead spread reductions.

These implications are examined by constructing block exclusion tests in bivariate VARs that include changes in the loan-deposit spread and one of the

[12] The share of loans and non-government securities in the asset portfolios of New York City national banks rose gradually from 49.8% in 1872 to 66.8% by 1915, and was relatively steady thereafter. The ratio for all national banks followed a similar time path prior to 1915, but continued to rise slowly over the 1920s.

Table 6
Bi-variate VARs with changes in the New York City spread and possible explanatory variables

	Spread equation			Explanator equation		
Explanator	SPR	EXPL	R^2/(DW)	SPR	EXPL	R^2/(DW)
NYCLS/ASSET	– 0.175	– 1.191	0.143	0.008	0.713	0.469
59 observations	(0.575)	(0.081)	(2.08)	(0.856)	(0.000)	(2.14)
NYCCLEAR/DEP	– 0.279	– 0.611	0.165	– 0.015	0.636	0.353
59 observations	(0.082)	(0.042)	(2.03)	(0.953)	(0.000)	(1.91)
NYCPROF/ASSET	– 0.315	– 1.707	0.257	– 0.052	0.608	0.454
59 observations	(0.325)	(0.002)	(2.06)	(0.337)	(0.000)	(1.93)
FORINV	– 0.485	– 0.041	0.138	1.960	0.833	0.640
42 observations	(0.114)	(0.358)	(2.03)	(0.154)	(0.000)	(1.93)
UKINV	– 0.424	– 0.028	0.111	0.826	0.721	0.419
42 observations	(0.183)	(0.609)	(2.05)	(0.398)	(0.000)	(1.87)
UKSPR	0.265	– 0.543	0.323	– 0.015	0.841	0.611
59 observations	(0.005)	(0.344)	(2.12)	(0.758)	(0.000)	(2.18)
FEDTAX	– 0.319	0.005	0.113	– 0.002	0.888	0.839
42 observations	(0.222)	(0.585)	(2.03)	(0.625)	(0.000)	(1.95)

Notes: Each line reports the sums of the regression coefficients on the loan–deposit spread in New York City and the explanatory variable listed at the left in a bi-variate VAR, with the significance level of the F-test for Granger causality in parentheses. It also includes the R^2 and Durbin–Watson statistics for each equation. The systems use two lags of each variable except for the system with UKSPR, which uses three lags. Lag order was determined with nested likelihood ratio tests. Systems with 59 observations cover the 1872–1929 period, while systems with 42 observations cover 1872–1913. The qualitative findings are all robust to specifications with an additional lag.

possible spread determinants.[13] The upper panel of Table 6 indicates that all three innovation proxies Granger-cause changes in the New York City loan-deposit spread at the 10% level or less, with no evidence of feedback. The signs of the coefficients on the spread determinants are also consistent with the role for innovation in spread reductions implied by the example in Section 3.

Of course, there are other plausible explanations for movements in the loan-deposit spread over this period that do not directly involve financial innovation. Certainly, as US investments became increasingly recognized as both reasonably safe and highly profitable outlets for foreign funds, the resulting capital inflows may have eased upward pressure on lending rates and caused deposit

[13] ADF tests with three lags and Phillips–Perron tests reject the null hypothesis of a unit root at the 10% level or less for all of the possible spread determinants.

rates to rise to attract such funds. However, while the stocks of foreign investment from the UK (UKINV) and all sources (FORINV) did indeed rise from \$1.68 and \$1.45 billion respectively in 1872 to \$3.97 and \$2.81 billion in 1896,[14] the discussion in Section 5.4 suggests that deposit rates were relatively steady in the late 1880s and early 1890s, which is the period during which foreign inflows grew most rapidly. In addition, the lower panel in Table 6 shows that annual real growth rates for these quantities over the 1872–1913 period (the years over which continuous series are available) do not Granger-cause the spread. Combined with a shift in the long-run direction of net capital flows from 1902–1914 despite generally higher interest rates in the US than the UK, the available evidence thus largely supports Cagan's (1965) view that real productive opportunities rather than interest rate differentials were the key determinants of long-run capital flows.

Amalgamation among UK banks prior to 1900 and an accompanying decrease in competition and widening of loan-deposit spreads (see Capie and Webber, 1985), to the degree that the US and UK money markets were becoming increasingly integrated, may also explain movements in US spreads. The available evidence, however, suggests that US spreads were falling throughout the 1890s. In addition, the tendency for the Federal Reserve and the Bank of England to share information about upcoming interest rate changes after the First World War also exerted influence on US interest rates, but would have affected spreads much less by this time. The lower panel of Table 6 confirms these notions by showing that the UK loan–deposit spread (UKSPR) did not Granger-cause the New York City spread.[15]

There were several changes in federal tax laws over the National Banking period that could have impacted bank profits and thus loan-deposit spreads. The most important was the repeal on 3 March 1883 of a 0.25% semiannual tax on deposits and capital in excess of that held in US bonds. In fact, net yields of national banks from 1883 to 1884 fell by 1% in New York City and 0.5% in the aggregate. A return to their 1882 levels by 1886, however, suggests that this movement was transitory. Other tax changes were designed to shift the timing and disposition of transfers. For example, by the Act of 12 July 1882 national

[14] Data on capital flows over the postbellum period were obtained from Dunning (1970), who extends the series originally published by Simon (1960). Intermittent data on capital inflows after 1913 are available from Bureau of the Census (1973).

[15] Since the UK spread (from Capie and Webber, 1985) rises gradually to the level of the New York City spread by 1929, it is not surprising that the series are cointegrated when non-stationarity is imposed. In this case, it is appropriate to test for Granger causality by adding an additional lag to a levels VAR specification, since this ensures a Wald distribution for the test statistic (see Toda and Yamamoto, 1995).

banks could avoid state taxes on circulation supported by 3% US bonds rather than the existing 3.5% bonds. This essentially generated revenue for the federal government at the expense of states, yet would have had only a small effect on bank profits. A similar impact might be expected from the Act of 14 March 1890, which reduced the semiannual circulation tax from 0.5% to 0.25% for banks that substituted 2% US bonds for the 3% issues.

The Comptroller's reports allow construction of a continuous series for the quantity of federal bank taxes prior to 1914,[16] but the presence of substantial state taxes on national banks render this series incomplete. To the degree that state tax rates were similar in the aggregate to national bank taxes prior to 1883 (when the Comptroller ceased to publish state figures) and subject to federal ceilings (Welch, 1934), some value may still be added by using the federal data to evaluate the impact of taxes on the spread. However, the last row of Table 6, which uses the ratio of federal taxes to capital for all national banks (FEDTAX) as a possible spread determinant, does not suggest that bank taxes had a significant impact.

Since required reserves were not available to meet liquidity needs, they were also a tax that may have kept spreads wider and influenced their permanent movements. Nevertheless, net yields of national banks moved very little when US deposits were exempted from reserve requirements in 1902. Additional provisions attached to later reserve legislation offset changes in required percentages. For example, a reduction in 1914 helped member banks to finance the compulsory purchase of capital stock in Federal Reserve Banks and left little to support purchases of other earning assets. In 1917, another reduction also directed national banks to deposit all required reserves with a Federal Reserve Bank immediately, which reduced the amount of deposits that banks could create per dollar of high-powered reserves (Cagan, 1965) (pp. 182-3). Thus, while innovations that shifted the distribution of deposits between national and non-national banks and between demand and time deposits may account for observed reductions in the ratios of required and actual reserves to deposits for commercial banks, the reductions were not a result of reserve legislation, and the role of the actual ratio in narrowing spreads is consistent with interpreting it as a proxy for innovation.[17]

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[16] This series includes taxes on deposits and capital from 1872–1882, taxes on capital authorized by the Act of 1898 from 1898–1902, corporation tax from 1909–1913, and taxes on circulation, assessments for the cost of plates, and examiner's fees from 1872–1913.

[17] The loan–deposit spread in New York City and the reserve ratio for all commercial banks (from Cagan, 1965, pp. 356–7) are cointegrated at the 5% level, and a bi-variate vector error correction model constructed with the estimated cointegrating vector and three lags indicates that the spread adjusts downward when the reserve ratio falls.

7. Conclusion

The preceding sections describe a mechanism through which technological improvements in the intermediating sector can affect financial depth by influencing the interest rate setting decisions of lenders and the application decisions of loan seekers. Specifically, an increased ability to monitor loan recipients eases the burden of defaults for lenders, and allows them to lower interest rates on loans. In an economy with asymmetric information between borrowers and lenders, limited liability for borrowers and a risk–return tradeoff, these actions induce higher–quality borrowers to seek intermediated finance. Competition among lenders for loanable funds then eliminates any temporary profits through increases in the deposit rate as the innovation diffuses through the intermediating sector. The result is an intermediating sector that is both larger and more efficient.

An empirical specification that is consistent with the proposed mechanism is then considered. The specification implies that the data generating processes for financial depth and the loan-deposit spread include independent and non-stationary stochastic trends, and allows movements in the permanent component of the spread to induce changes in financial depth that cannot be predicted by the past history of the financial variable alone. The results verify the independence and non-stationarity implications in US data over the 1872–1929 period, and indicate that reductions in the permanent component of the spread had consistently positive and statistically significant effects on financial depth. Proxies for financial innovation are also linked to spread reductions. Overall, the study offers new evidence in support of a possible mechanism through which efficiency improvements affected asset accumulation by intermediaries in the pre-1930 United States.

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Appendix A.

This appendix describes the sources and methods used to create the series used in the econometric analyses. All figures are annual and from the closest reporting date to June 30 unless otherwise noted.

GNP	nominal gross national product; 1872–1929 are annual averages from Balke and Gordon (1986) table 1, col. 1, pp. 781–3.
SPR	proxy for loan to deposit rate spread; 1872–1919 are net returns of New York City banks; 1872–1914 are from Davis (1965) table 4, p. 362; 1915–1919 were collected from annual issues of the *Report of the Comptroller of the Currency*; 1920–1929 are differences between the average business loan rate charged by New York national banks and the regular deposit rate of the Bowery Bank of New York, with the loan rate from the Bureau of the Census (1973) series X471, p. 1002, and the deposit rate from Homer and Sylla (1996), table 49. A ratio splice connects the 1872–1919 with the 1920–1929 components.
NATA	total assets of national banks; 1872–1929 are from the Bureau of the Census series X635, pp. 1024–7.
NNATA	total assets of non-national banks; 1872–1929 are from Bureau of the Census series X657 pp. 1028–30. These totals include the assets of reporting State commercial banks, private banks, and mutual savings banks.
NNATADJ	total assets of non-national banks after adjustment for non-reporting and under-reporting banks; 1872–1896 apply the ratio of 'corrected' deposits (from Bureau of the Census series X678, p. 1030) to reported deposits (from Bureau of the Census series X670, pp. 1028–30) to the NATA series above. The original source of the adjusted series is Fand (1954).
BANKA	sum of NATA and NNATA series.
BNKADJ	sum of NATA and NNATADJ series.
LI	total assets of life insurance companies; 1872–1929 from Bureau of the Census series 908, p. 1060.
PENS	total assets of pension funds; 1920–1929 from Goldsmith (1955) table 1-16(1), p. 469 'assets of private independent pension funds'.
FIRMAR	total assets of other insurance companies; 1896–1929 are sum of Goldsmith (1955) table V-55(1), p. 553 'assets

of fire and marine insurance companies' and table V-56(1), p. 555 'assets of casualty and miscellaneous insurance companies'.

INVCOS total assets of investment companies; 1914–1929 are sum of Goldsmith (1955) V-60(1), p. 559 'assets of open-end management investment companies 1924–1949', table V-62, p. 563 'assets of closed-end management investment companies 1921–1949', table V-69, p. 571 'assets of fixed and semi-fixed investment trusts 1927–1949', and table V-72, p. 573 'assets of face amount installment investment companies 1914–1949'.

FIA total assets of available financial intermediaries; 1872–1929 is sum of BNKADJ, LI, FIRMAR, PENS, and INVCOS above.

NYCCAP/ASSETS ratio of total paid-in capital for national banks in New York City to total assets; 1872–1929 from annual issues of the *Report of the Comptroller of the Currency*.

NATCAP/ASSETS ratio of aggregate paid-in capital for national banks to total assets; 1872–1929 from annual issues of the *Report of the Comptroller of the Currency*.

NYCCLEAR/DEP ratio of value of transcations at the New York clearing-house to deposits at New York City national banks; 1872–1929 from *Report of the Comptroller of the Currency*, 1930, p. 759.

NYCLS/ASSETS ratio of loans, stocks, bonds and other private security holdings of national banks in New York City to total assets; 1872–1929 from annual issues of the *Report of the Comptroller of the Currency*.

NYCPROF/ASSETS ratio of undivided profits and surplus for national banks in New York City to total assets; 1872–1929 from annual issues of the *Report of the Comptroller of the Currency*.

FORINV direct foreign investment in the US; 1872–1913 from Dunning (1970), table 1, col.3, pp. 178–81.

UKINV direct foreign investment in the US from UK sources; 1872–1913 from Dunning (1970), table 1, col.12, p. 178–81.

UKSPR	bank rate less deposit rate in the UK; 1872–1929 from Capie and Webber (1985), table III.(10), pp. 508–17.
FEDTAX	ratio of federal bank taxes to paid-in capital, including taxes on circulation, deposits, capital, corporation tax, the cost of plates and examiner's fees; 1872–1929 from annual issues of the *Report of the Comptroller of the Currency*.

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