Currency Elasticity and Banking Panics: Theory and Evidence

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The original developments of Bryant (1980) and Diamond–Dybvig (1983) spawned a large literature on bank panics and suspensions of convertibility. This literature has been useful in providing operational definitions of bank liquidity provision and in giving a clear view of the potential difficulties caused by a natural mismatch of maturities between bank assets and liabilities. The literature has also formalized a number of contemporary explanations for the occurrence of panics/suspensions, including self–fulfilling prophecies (Diamond–Dybvig 1983), excessive competition for deposits (Smith 1984), and adverse inferences caused by heavy ("fundamental") withdrawal demand (Chari–Jagannathan 1989).

The apparently very different panic experiences of banking systems operating under different regulatory regimes has also led to work exploring the role of the environment in which banks operate in fostering or deterring panics. For instance, the dramatically different panic experiences (or lack thereof) in the U.S. and Canada is well documented (Breckenridge 1910, Johnson 1910, Myers 1931, Williamson 1989, Haubrich 1990), and a number of authors have pursued different explanations of why Canada was able to avoid the frequent panics observed in the U.S.[1] For instance, in contrast to the system in effect in the U.S., Canadian banks were able to branch freely. White (1984), Williamson (1989), and Smith (1990) pursue this as a potential explanation for the relative stability of the Canadian banking system. Somewhat relatedly, the Canadian system appears to have been conducive to a greater degree of cooperation/collusion among individual banks than was the U.S. system. Some contributions (Smith 1984, Williamson 1989, Calomiris 1989a, b, Calomiris–Gorton 1990) identify this as a possible stabilizing feature.

All of the theoretical contributions listed thus far consider purely "real" economies—ones that lack a role for currency.[2] We argue that there are at least four important reasons to expand this literature in the direction of introducing monetary considerations.

First, operational definitions of panics involve currency in a central way. For example, the defining characteristics of a banking panic, according to Noyes (1909, pp. 186–7), include the suspension of cash payments by banks to depositors, the depletion of cash reserves at banks, the emergence of a currency premium, and the adoption of "emergency expedients... to provide the necessary medium of exchange for ordinary business."

Second, most contemporary proposals for reforming the U.S. banking system reflected a belief regarding an intimate relationship between the monetary system and the occurrence of panics. Such reforms of the monetary and banking systems were proposed in the "Baltimore Plan" of 1894 and by the Indianapolis Monetary Commission of 1900 (West 1977, pp. 43–5). Some proposals argued that the United States should have a monetary system like that of Canada, which had a "truly elastic currency" (Laughlin 1912, p. 130). The desire to reform the system for issuing currency and/or banknotes was also reflected in the Aldrich–Vreeland Act and the Federal Reserve Act.

Third, a number of contemporary observers [including Laughlin (1912), p. 312] argued that the system of banknote issues was more important than branching restrictions in explaining the apparent stability of the Canadian banking system. And fourth, a great deal of our empirical knowledge about banking panics, such as that summarized in Friedman and Schwartz (1963) or Miron (1986), concerns the behavior of money, credit, the reserve–deposit and currency–deposit ratios, and nominal interest rates during panic episodes. Clearly an understanding of these observations requires that monetary factors be integrated in existing banking models.

The objective of this paper is to develop a model in which the mechanisms for money creation and the provision of liquidity by banks are interrelated. In doing so, we also attempt to capture some contemporary explanations of banking panics, in which seasonal variations in the demand for credit and liquidity play a role. For instance, Andrew (1908a) and Sprague (1910) [see also Goodhart 1969 for a concise summary] argued that significant seasonal strains were placed on the banking system during periods of "crop–moving," when both credit demands and liquidity needs tended to be greatest. At these times relatively small incremental shocks to the demand for currency could push the banking system into a panic. While this view was widely held by contemporary observers (and subsequent students, such as Goodhart), it has found little reflection in existing models of panics (important exceptions include Miron 1986 and Chari 1989). In fact, it has come under some historical (Patterson 1913) as well as more recent (Calomiris–Gorton 1990) attack. Our analysis provides some new perspective on this discussion, and in fact shows how the Andrew–Sprague account of events can be correct, even given the truth of the criticisms made by Patterson and Calomiris–Gorton.

In the sequel, we undertake both a theoretical, and a reasonably detailed but largely informal empirical analysis of these issues. In section 1 we develop a model where, as in Diamond–Dybvig (1983), banks exist in part to insure agents against random needs for liquidity. However our banks also intermediate between lenders and borrowers. More specifically, we consider a pure exchange economy with overlapping generations of two–period–lived consumers. Within each generation some agents are lenders and some are borrowers. Moreover, agents are assigned to either of two locations. After exchange and consumption occur in the first period, a randomly selected fraction of lenders is forced to relocate. As in Townsend (1987), Mitsui–Watanabe (1989), or Hornstein–Krusell (1990), only paper liabilities can be transported between locations, and limited communication prevents claims on specific agents from being traded across locations. This generates a transactions role for currency. Moreover, the possibility of relocation takes the place of "preference shocks" in Diamond–Dybvig (1983); in the event of relocation an agent needs liquidity. Banks, in addition to making loans, hold reserves (and possibly issue notes), and write deposit contracts insuring lenders against the possibility of relocation. Thus the monetary and banking systems are intimately related.

In addition to aggregate (as well as individual) randomness associated with relocations, there are two sources of deterministic seasonal variations in the model. As in Sargent–Wallace (1982), which in many ways our model resembles, there is a seasonal variation in credit demand. In addition, we introduce seasonal variations in "liquidity preference," captured here by changing the probability distribution of relocation in a seasonal fashion. In the model, high credit demand and greater liquidity preference coincide seasonally, as Laughlin (1912, pp. 314–5) argues was true historically. This is an attempt to capture the seasonal impacts on historical financial markets associated with the needs of "crop–moving" in a highly agricultural economy.

Having constructed the model, we then consider two banking regimes. In the first banks can issue notes, which are default–free claims to currency, against general assets. In the second banks are prohibited from issuing notes, so that currency is entirely a liability of the government. We are interested in contrasting the operating characteristics of these two systems, the first of which we refer to as an "elastic" and the second as an "inelastic" currency regime. These regimes, as well as the model itself, are set up with the data in mind; in particular, they are designed to capture certain im-

portant features of the banking environments in Canada and the U.S. during the period 1880–1910. This period contains that of the National Banking System in the U.S. (1863–1913), during which all U.S. currency was either a direct liability of the government, or in the form of national banknotes backed by government bonds (being, therefore, *de facto* liabilities of the government). Moreover, the mechanics of note issue severely limited currency elasticity, so that our inelastic currency regime captures some essential features of the U.S. system. In Canada at this time, chartered banks were free (except for limitations imposed by capital requirements and denominational restrictions) to issue notes against general assets. Institutional arrangements served to make these notes essentially default–free (Johnson 1910, Breckenridge 1910, Williamson 1989), so that our elastic currency regime corresponds to the Canadian system.

In the elastic currency regime, banks can use note issues to completely accommodate withdrawals arising from relocations. In this situation there is a Pareto optimal equilibrium, bank panics do not occur, and the nominal interest rate is always zero. The price level, credit, and the inside money stock fluctuate seasonally, so that as in Sargent–Wallace (1982), this "real–bills" regime concentrates fluctuations in the stock of inside money and the price level, rather than nominal interest rates. In contrast to Sargent–Wallace (1982), however, our "real–bills" regime appears to display the potential for indeterminacy in the price level and the stock of inside money, which we explore briefly.

Under the inelastic currency regime the nominal interest rate is positive and varies seasonally, being highest in periods of greatest financial market pressure. In addition banking panics occur with positive probability, where a panic corresponds to a situation of complete exhaustion of bank reserves and suspension of cash payments. Since other bank assets are illiquid, this event precludes depositors from being fully insured. However, in contrast to Diamond–Dybvig, our panics are the result of fundamentals. There is no private information and, in the event of a panic payments are made optimally to agents making withdrawals (in particular there is no sequential service constraint). The probability of a panic is highest in periods of greatest seasonal "pressure," and in the event of a panic a currency premium can be observed. Moreover, a panic will correspond to the attainment of a critical value by the currency–deposit ratio, which is exactly how panics are described by Friedman

and Schwartz (1963, p. 56, 109, 122, 158, 333), for instance. Finally, of course, the inelastic currency regime does not support a Pareto optimal equilibrium, although it does appear to avoid some of the sources of indeterminacy that arise under the "real–bills" regime. Some of these issues are discussed in section 2.

Section 3 undertakes an analysis of monthly data on loans, deposits, reserves, note issues, and nominal interest rates for the U.S. and Canada over the period 1880–1910. The data are decomposed into a trend, a seasonal, and a cyclical component, and seasonal and cyclical components are contrasted with the implications of the model. As the model predicts, the Canadian data display greater seasonal variation of banknotes in circulation than in the U.S., which permits less seasonal variability in loans, deposits, and nominal interest rates. In Canada loans expand in the autumn to accommodate crop–moving needs; whereas in the U.S. loans contract at this time and nominal interest rates rise.

With respect to cyclical variability, Canadian banknote issues rise markedly (but not exclusively) during panic periods in the U.S. This permits Canadian banks to avoid the loss of cash reserves at these times, in marked contrast to their U.S. counterparts. Also, when the U.S. was experiencing panics Canadian banks followed Bagehot's (1876) dictum of liberally expanding loans. This did not occur in the U.S.

Section 4 comments on the Andrew–Sprague–Goodhart "seasonal plus shock" theory of panics, discussing how the analysis permits this view to be reconciled with the Patterson/Calomiris–Gorton criticism. Section 5 offers concluding comments.

1. The Model

1.1. *Environment*

We consider an overlapping generations economy, with time indexed by $t = 1, 2, \ldots$. In each period, a continuum of two–period–lived agents with unit mass is born at each of two locations. Half of these agents are "lenders" and the remaining half are "borrowers." All agents have preferences given by $u(c_1, c_2) = \ln c_1 + \beta \ln c_2$, where $c_j \in \Re_+$ denotes consumption in period j of life. Lenders have an endowment $x > 0$ of the nonstorable consumption good when young and no endowment

when old. Borrowers have no endowment when young, and a borrower born at date t has an endowment y_t when old, where $y_t = y_o$ for t odd and $y_t = y_e$ for t even, with $y_o > y_e > 0$. Also, we assume that $(\beta x)^2 > y_o y_e$, which implies that this is a "Samuelson case" economy (in Gale's 1973 usage). At $t = 1$ there is a continuum of old agents with unit mass in each location. These agents are each endowed with M units of fiat currency, where $M > 0$, and there are no subsequent injections or withdrawals of currency.[3]

As is typical in models where movement between locations is taken seriously, the timing of events within a period and the pattern of meetings between agents is of considerable importance. At the beginning of each period agents in each location receive their endowment. At this time young lenders are able to deposit resources with a bank, whose behavior is described below, and they can also trade with old agents. After making these transactions young lenders consume, and are then unable to make contact with other agents until they learn whether or not they are to be relocated. (In particular, young lenders and young borrowers never meet.) Young borrowers contact the bank next, taking loans in a way we describe below. After loans have been made, young lenders learn whether or not they are to be relocated. At time t a randomly selected fraction π_t of young lenders is relocated, with π_t being the same in each location (to preserve symmetry). The lenders who are to be relocated are then able to contact their bank, withdrawing their deposits plus any promised interest. Since all time t resources have been consumed, these agents receive claims to future consumption in the form of either banknotes or currency. Having obtained these, relocation occurs. Then at t+1 these liabilities can be used to purchase goods when old agents contact young lenders and/or the bank in their new location. Banknotes (if they exist) and currency are assumed to be perfect substitutes, and we assume that neither can be counterfeited.

The relocation probability π_t is itself assumed to be a random variable, which is drawn from the distribution $F_t(\cdot)$. We assume that $F_t(\cdot) = F_o(\cdot)$ for t odd and $F_t(\cdot) = F_e(\cdot)$ for t even, with $F_o \geq F_e$ in the sense of first order stochastic dominance [i.e., $F_o(\pi) \leq F_e(\pi)$, $\forall\ \pi$]. The distribution function $F_t(\cdot)$ has the associated continuously differentiable density function $f_t(\cdot)$; $t = o, e$. Finally, we assume that a young lender's status as a mover or nonmover is publicly observable and that bank payments can be made contingent on this status.

Remarks

The basic structure of the model is similar to that of Sargent–Wallace (1982), with two "seasons" and seasonal variation in credit demand. We have added the feature that individuals have idiosyncratic and random needs for liquid assets (assets that can be used in other locations), as in Diamond–Dybvig (1983). The nature of interlocation exchange introduces a role for a medium of exchange that is familiar from Townsend (1987), Mitsui–Watanabe (1989), and Hornstein–Krusell (1990).

Relative to Sargent–Wallace (1982), we have also introduced seasonal factors affecting the demand for media of exchange [through the seasonal variations in the distributions $F_t(\cdot)$] as well. Our interest is in part to see how different banking regimes respond to these seasonal factors affecting the demand for credit and liquidity. Andrew, Sprague, and Goodhart, for instance, argue that this issue is intimately connected with the occurrence (or in Canada non–occurrence) of panics. We have assumed that credit and liquidity demands (in a probabilistic sense) tend to be high simultaneously. Laughlin (1912, pp. 314–5) argues that this is an historically accurate description of the pressures placed on financial markets by crop–moving in the agricultural economies of the U.S. and Canada.

It is also clearly essential that interlocation exchange be accomplished with currency or banknotes. In the model this can be viewed as a consequence of the nature of meetings and of limited communication between locations. In particular, private (non–bank, non–government issued) claims on resources cannot be traded across locations for the following reason. Old agents who have relocated at t–1 meet young agents at t before contact is made (relocations occur) with the other location. If these old agents could issue claims against the other location (for instance write checks against deposits left in their bank there), there would be no limit to the number they could create, since clearing between locations cannot occur until the locations are in contact. By the time this contact has occurred old agents have consumed, so that no penalization of this activity is possible. It is therefore infeasible for privately issued claims to be traded across locations. We believe that this in fact captures an important historical phenomenon, for as Sprague (1910, p. 75) asserted, "in making payments at a distance local substitutes for money will not serve," where "local substitutes" includes checks or other private liabilities.[4]

An assumption that merits comment is the specification that precludes borrowers and lenders from meeting. In particular, this may appear to force there to be intermediation between borrowers and lenders, hence forcing a role for banks. In fact, the role for banks in the model is exactly to insure against random liquidity needs. The assumption that borrowers and lenders do not meet is entirely innocuous except in our discussion of currency premia in section 2.3. Its role is discussed further at that point.

Finally, we comment on the assumption that agents have logarithmic utility. This assumption plays no role when banks are note issuing, except to make the analysis comparable to that of Sargent–Wallace (1982). When banks are not note issuing, the assumption of logarithmic utility permits a separation of the savings problems of lenders and the contracting problem of banks (see below). This is essential for tractability.

1.2. *Behavior of Agents*

We assume that there is a fixed, finite set of banks at each date in each location. These banks take deposits, hold reserves, and make loans. In addition banks announce payoff schedules at t which specify gross real returns to depositors contingent on type (mover versus nonmover) per unit deposited. We let $r_t^m(\pi_t)$ $[r_t(\pi_t)]$ denote the one period return for movers (nonmovers), contingent on π_t. Each bank announces such a schedule, taking the announcements of other banks as given. Once return schedules are announced each bank simply accepts all deposits offered, and makes loans charging the competitively determined gross (real) loan rate R_t.[5]

Having observed announced repayment schedules at t, each lender chooses a savings level (or deposit) d_t, and a bank. As in Diamond–Dybvig (1983) all savings will be deposited, so d_t is chosen to maximize the lender's expected utility, which is

$$\ln(x - d_t) + \beta\int_0^1 \pi \ln[r_t^m(\pi)d_t]f_t(\pi)\,\mathrm{d}\pi + \beta\int_0^1 (1-\pi)\ln[r_t(\pi)d_t]f_t(\pi)\,\mathrm{d}\pi.$$

The solution to this problem sets $d_t = \beta x/(1+\beta)$, and each lender chooses the bank whose return schedules maximize this expression.

Borrowers observe the competitively determined gross loan rate R_t at t, and choose a loan quantity l_t to maximize $\ln l_t + \beta \ln(y_t - R_t l_t)$. The solution to this sets $l_t = y_t/(1+\beta)R_t$.

The Bank's Problem

Banks announce return schedules, take deposits, make loans, hold currency and reserves, and (possibly) issue notes. Thus banks face a non–trivial portfolio allocation problem, which obviously affects what return schedules can be announced. We now describe the choices open to banks.

Each bank (that obtains any deposits) will have per capita deposits with a real value of d_t at t. Against these the bank holds per capita cash reserves with a real value of z_t, and makes loans with a real value of $d_t - z_t$. Let $\gamma_t \equiv z_t/d_t$ be the bank's reserve–deposit ratio. Loans earn the one period gross return R_t, and reserves earn the one period real gross return p_{t+1}/p_t, where p_t is the time t *inverse* price level. The bank takes R_t and p_{t+1}/p_t as given.

After γ_t is chosen and loans are made at t, π_t is realized. Then the bank faces real per capita withdrawal demand equal to $d_t \pi_t r_t^m(\pi_t) p_t/p_{t+1}$.[6] This payment is made by the bank in the form of currency or notes; since borrowers have no resources at t there is no ability to liquidate loans.[7] Movers then take the currency or notes to their new location, where they are used to make purchases at t+1.

Let $\alpha_t(\pi_t)$ denote the fraction of its cash reserves that the bank pays out at t (as a function of π_t), and let $b_t(\pi_t)$ be the real per capita value of notes issued by the bank at t. Then payments to movers at t must satisfy the constraint

$$(1) \qquad \pi_t r_t^m(\pi_t) p_t/p_{t+1} \le \alpha_t(\pi_t)\gamma_t + b_t(\pi_t)/d_t,$$

or equivalently,

$$(1') \qquad \pi_t r_t^m(\pi_t) \le \alpha_t(\pi_t)\gamma_t p_{t+1}/p_t + b_t(\pi_t) p_{t+1}/d_t p_t.$$

Payments to nonmovers at t+1 are $(1-\pi_t)d_t r_t(\pi_t)$. These cannot exceed the value of the bank's remaining assets, which are its remaining reserves plus its loan repayments. Also, if the bank retires (or redeems) all notes issued at t, this absorbs resources equal to the real value of note issues

times the gross return on notes; i.e., $b_t(\pi_t)p_{t+1}/p_t$ per capita. Therefore, assuming complete redemption of time t note issues at $t+1$,

$$(2) \qquad d_t(1-\pi_t)r_t(\pi_t) \le d_t\gamma_t[1-\alpha_t(\pi_t)]p_{t+1}/p_t + d_t(1-\gamma_t)R_t - b_t(\pi_t)p_{t+1}/p_t.$$

Finally, we impose the constraints $0 \le \gamma_t \le 1$; $0 \le \alpha_t(\pi_t) \le 1$, and $0 \le b_t(\pi_t)$.

1.3. *Nash Equilibrium Return Schedules: Note Issue Permitted*

We now describe Nash equilibrium contract announcements by banks under the assumption that note issue is unrestricted. Clearly any Nash equilibrium has banks earning zero profits; therefore (1) and (2) hold with equality in equilibrium. In addition, competition among banks for deposits implies that Nash equilibrium contract announcements must maximize the expected utility of depositors, taking "deposit demand schedules" as given.[8] Since $d_t = \beta x/(1+\beta)$, $r_t^m(\pi_t)$, and $r_t(\pi_t)$ must (in equilibrium) be chosen to maximize the expression

$$\ln[x/(1+\beta)] + \beta\int_0^1 \pi \ln[r_t^m(\pi)\beta x/(1+\beta)]f_t(\pi)\,d\pi$$

$$+ \beta\int_0^1 (1-\pi)\ln[r_t(\pi)\beta x/(1+\beta)]f_t(\pi)\,d\pi,$$

subject to (1), (2), and the standard non-negativity constraints. Of course R_t and p_{t+1}/p_t are taken as given in this maximization.

The solution to this problem satisfies (1) and (2) with equality, and sets $r_t^m(\pi_t) = r_t(\pi_t)$ $\forall\ \pi_t$. Therefore

$$(3) \qquad r_t^m(\pi_t) = r_t(\pi_t) = \gamma_t p_{t+1}/p_t + (1-\gamma_t)R_t.$$

In addition, $\gamma_t = 0$ (1) if $R_t > (<)\ p_{t+1}/p_t$. Thus an equilibrium with loans and valued fiat currency has $R_t = p_{t+1}/p_t$. This is equivalent to loans bearing a zero nominal interest rate. In this situation γ_t is indeterminate, from the standpoint of any *individual* bank. It is also the case that the schedules $\alpha_t(\pi_t)$ and $b_t(\pi_t)$ are not uniquely determined. However, from (1) and (3),

(4) $\alpha_t(\pi_t)\gamma_t + b_t(\pi_t)/d_t = \pi_t.$

Here, $\alpha_t(\pi_t)\gamma_t d_t$ is the amount of its cash reserves the bank pays to its depositors at t, and $b_t(\pi_t)$ is the bank's note issue (in real terms). Thus, the quantity of circulating media of exchange transferred from banks to depositors is determined at each date.

Banknote Redemptions

The preceding discussion has proceeded under the assumption that all banknote issues are always redeemed after one period. We now show that this is, in fact, an equilibrium outcome.

At date t movers bring banknotes and currency to their new locations. These are held until t+1, when they are used to purchase goods from young agents (these transactions could also be intermediated by banks). All currency and banknotes end up being deposited in banks. Let $\hat{b}_{t+1}$ denote the real value, in per capita terms, of notes issued by other banks that some individual bank receives. This bank could either return the notes for redemption or hold them as reserves. Let b^*_{t+1} denote the per capita quantity of notes (in real terms) that the bank sends for redemption.

Similarly, the bank in question will have issued some notes in the past, which have not yet been redeemed. We let b_{t+1} denote the per capita real value of the bank's own outstanding notes at t+1. Further, let $\tilde{b}_{t+1} \leq b_{t+1}$ be the value of these notes sent for redemption at t+1. Then the bank's balance sheet constraint at t+1 is $l_{t+1} + z_{t+1} + \hat{b}_{t+1} - b^*_{t+1} \leq d_t - \tilde{b}_{t+1}$, where l_{t+1} denotes per capita loans.

Now banknotes and currency are perfect substitutes, and both are perfect substitutes for loans if $R_t = p_{t+1}/p_t$. Thus the bank is indifferent regarding the composition of its portfolio, and each bank is therefore willing to redeem all the notes it obtains at each date; i.e., $\hat{b}_{t+1} = b^*_{t+1}$ and $\tilde{b}_{t+1} = b_{t+1}$, $\forall\ t$. Throughout we focus on equilibria in which all banknote issues are redeemed at the earliest opportunity.[9]

This raises the issue of whether there are equilibria in which not all banknote issues are redeemed at the earliest opportunity. The question itself is suggestive of a coordination problem in issuing and redeeming liabilities, of the sort discussed by Townsend–Wallace (1987). While we do

not formally pursue this here, we comment further on the possibility below. However, we might observe that, to the extent that any bank perceived itself as facing limitations on its own note issues (perhaps because of limitations imposed by paid–up capital, which Canadian banks faced), this would increase the incentives for the prompt redemption of the notes of other banks. And in fact, historical Canadian note issues appear to have been returned fairly rapidly for redemption (Johnson 1910, p. 23).

1.4 *General Equilibrium: Note Issues Permitted*

We now describe the determination of a full general equilibrium with valued fiat currency (under the assumption that all notes are redeemed in one period). Then $R_t = p_{t+1}/p_t$, $\forall\ t$. Moreover, the net per capita savings of each young generation must equal the per capita supply of real balances in each period, so that, $\forall\ t$,

$$(5) \qquad \beta x/(1+\beta) - y_t/(1+\beta)R_t = p_t M.$$

Finally, all real balances are held as cash reserves by banks, so that in equilibrium

$$(6) \qquad \gamma_t d_t \equiv \gamma_t \beta x/(1+\beta) \equiv p_t M.$$

As in Sargent–Wallace, we confine attention to periodic equilibria where $R_t = R_i$, $p_t = p_i$, and $\gamma_t = \gamma_i$, where $i = o$ for t odd and $i = e$ for t even. Substituting $R_t = p_{t+1}/p_t$ into (5), and using (5) for $t = o, e$, gives

$$(7) \qquad \frac{\beta x - (y_o/R_o)}{\beta x - (y_e/R_e)} = p_o/p_e = R_e = 1/R_o.$$

Solving (7),

$$(8) \qquad 1/R_o = R_e = (\beta x + y_e)/(\beta x + y_o) < 1.$$

p_o and p_e can be obtained from (5) and (8), and γ_o and γ_e can then be obtained from (6). It is easy to verify that $p_e > p_o > 0$, and $\gamma_e > \gamma_o$. Thus real interest rates and the price level $(1/p_t)$ are highest

when credit demand is greatest. Notice that liquidity shocks have no effect on any equilibrium values; in particular, the probability distributions $F_t(\cdot)$ are themselves irrelevant for all equilibrium quantities. This is because when banks are note issuing, it is possible for them to perfectly insure against all relocation risk, as there is no aggregate randomness.[10]

It is also the case that there are no panics in this economy. A panic here (see section 2.1) occurs when banks are unable to provide sufficient media of exchange to allow $r_t^m(\pi_t) = r_t(\pi_t)$ to hold. When note issue is unrestricted, banks can always accomplish this simply by issuing notes, so no panics are possible.

We also observe that the equilibrium just derived is Pareto optimal. This follows from proposition 5.6 of Balasko–Shell (1980) and the fact that, in the equilibrium derived, $\lim_{T \to \infty} \inf \prod_{t=1}^{T} R_t = 1$.[11] Thus, when banks are note issuing, this economy has an equilibrium with a number of desirable properties.

1.5 *Empirical Implications*

In section 3 we will compare the predictions of the model with Canadian and U.S. data. As a prelude to doing so, we now mention several implications of the model. All of the implications we derive concern nominal interest rates and nominal quantities of bank assets, liabilities, and circulating media of exchange. Our focus on nominal quantities reflects the lack of adequate monthly price indices to be used in deflating the dollar denominated time series data.

First, the model implies that, under an elastic currency system, there should be no seasonal variation in nominal interest rates.[12] Second, the model implies that as much as 100 percent of withdrawals can be accommodated by issuing notes. Thus the model is consistent with little or no variation in cash reserves (seasonally or otherwise). Third, the model predicts that the quantity of circulating media of exchange will be greatest when withdrawal demand is greatest [as implied by equation (4)].

To derive the remaining implications, we measure quantities in terms of their "end of period" levels. The per capita quantity of circulating media of exchange (currency *in circulation* plus banknotes) at the end of period t is $\pi_t r_t^m(\pi_t) d_t p_t / p_{t+1}$ in real terms, since banks give currency and/or

notes to movers at t with a real value of $\pi_t r_t^m(\pi_t) d_t p_t / p_{t+1}$, and these assets earn the gross return p_{t+1}/p_t between t and t+1. Therefore, from (3) and $R_t = p_{t+1}/p_t$, the *nominal* value of circulating media at t is $\pi_t r_t^m(\pi_t) d_t / p_{t+1} = \pi_t \beta x/(1+\beta)p_t$. The average quantity of currency plus notes in circulation is therefore given by

$$\bar{C}_t = [\beta x/(1+\beta)p_t] \int_0^1 \pi f_t(\pi)\, d\pi; \quad t = o, e.$$

Since $p_o < p_e$ and $F_o \geq F_e$ in the sense of first-order stochastic dominance, it follows that $\bar{C}_o > \bar{C}_e$; i.e., the quantity of circulating media of exchange will be highest in seasons where credit demand and average liquidity needs are greatest.

With respect to total loans, nominal per capita loans at t are nominal deposits less nominal reserves; i.e.,

$$L_t = \beta x/(1+\beta)p_t - M; \quad t = o, e.$$

Then $p_e > p_o$ implies $L_o > L_e$, so that loans also increase in seasons of high credit demand and high average liquidity need. Finally, end of period deposits at t are just the nominal value of beginning of period deposits, $\beta x/(1+\beta)p_t$, less nominal withdrawals, $\pi_t \beta x/(1+\beta)p_t$. Therefore the total per capita quantity of deposits at the end of period t, in dollar terms, is given by $D_t = \beta x(1-\pi_t)/(1+\beta)p_t$. Average deposit levels satisfy

$$\bar{D}_t = [\beta x/(1+\beta)p_t] \int_0^1 (1-\pi) f_t(\pi)\, d\pi = [\beta x/(1+\beta)p_t] \int_0^1 F_t(\pi)\, d\pi; \quad t = o, e.$$

As $p_e > p_o$ and $F_e(\pi) \geq F_o(\pi)\ \forall\ \pi$ hold, apparently $\bar{D}_e \gtreqless \bar{D}_o$ is possible. Average nominal deposits will tend to be largest in odd periods if seasonal variations in credit demand are large relative to seasonal variations in average liquidity needs, and conversely.

2. An Inelastic Currency Regime

We now examine the operation of this economy when banknote issues are prohibited. A prohibition on note issues is intended to capture some of the regulations in force under the National Banking System (1863–1913) in the U.S. During this period all banknotes were fully backed by government bonds, and hence were *de facto* liabilities of the government. Moreover (and for our purposes more importantly), the mechanics of note issue under this system [see Champ (1990) for a complete description] precluded banknote issues from being used to forestall panics. While apparently U.S. banks did make efforts to expand their note issues during panics [see Figure 10 or Stevens (1894, p. 139)], the mechanism for issuing notes did not permit them to "get out into circulation until too late to do much good." (Laughlin 1912, p. 138) This view is supported by Secretary of the Treasury Carlisle's (1894, p. LXXV) statement that

> ...under the present laws, which do not authorize the Treasury Department to prepare and hold a reserve of blank bank notes ready for immediate delivery immediately upon application, from thirty to sixty days must ordinarily elapse before the issue can be made. Thus, the inducement to take out circulation when business necessities are greatest is very small, if it exists at all, and even if applications are made the circulation will probably not be secured until too late to afford relief.

Such a delay was too long a period of time to permit banknote issues to have much impact in responding to panic conditions. Thus a prohibition of note issues crudely captures an essential aspect of the National Banking System.

2.1. *Equilibrium Return Schedules*

When note issues are prohibited, banks operate as described in section 1.2, subject to the additional restriction that $b_t(\pi_t) \equiv 0$. Then it is apparent that competition for deposits will force zero profits in equilibrium. Moreover, this same competition will force equilibrium return schedules to be chosen to maximize the (indirect) expected utility of depositors, taking their savings behavior as given, subject to (1) and (2) at equality, $b_t(\pi_t) \equiv 0$, and non–negativity restrictions. Then in equilibrium, $r_t^m(\pi_t)$, $r_t(\pi_t)$, $\alpha_t(\pi_t)$, and γ_t must be chosen to maximize

$$\ln[x/(1+\beta)] + \beta\int_0^1 \pi \ln[r_t^m(\pi)\beta x/(1+\beta)] f_t(\pi)\, d\pi$$

$$+ \beta\int_0^1 (1-\pi) \ln[r_t(\pi)\beta x/(1+\beta)] f_t(\pi)\, d\pi,$$

subject to

(9) $\pi r_t^m(\pi) \leq \alpha_t(\pi)\gamma_t p_{t+1}/p_t,$

(10) $(1-\pi)r_t(\pi) \leq [1-\alpha_t(\pi)]\gamma_t p_{t+1}/p_t + (1-\gamma_t)R_t,$

$\gamma_t \in [0, 1]$, and $\alpha_t(\pi) \in [0, 1]$, $\forall\ \pi$. This maximization, as before, is performed taking R_t and p_{t+1}/p_t as given.[13] The solution to this problem satisfies (9) and (10) as equalities, along with

(11) $\alpha_t(\pi_t) \leq \pi_t\{1 + [(1-\gamma_t)/\gamma_t]R_t p_t/p_{t+1}\},$

where equality obtains if $\alpha_t(\pi_t) < 1$, and

(12) $\gamma_t = 1 - \int_{\pi_t^*}^1 F_t(\pi)\, d\pi.$

In (11), π_t^* is defined to be the value of π_t that satisfies (11) as an equality with $\alpha_t(\pi_t^*) = 1$; i.e.,

(13) $\pi_t^* \equiv \{1 + [(1-\gamma_t)/\gamma_t]R_t p_t/p_{t+1}\}^{-1} \equiv g(\gamma_t, I_t)$

where we henceforth let $I_t \equiv R_t p_t/p_{t+1}$ denote the (gross) nominal rate of interest.

It is apparent that for $\pi_t \leq \pi_t^*$, $\alpha_t(\pi_t) \leq 1$, while if $\pi_t \geq \pi_t^*$, $\alpha_t(\pi_t) = 1$. Then, when $\pi_t \geq \pi_t^*$ holds, the banking system exhausts its cash reserves. As suggested by Noyes (1909), we associate this event with a panic. Apparently $r_t^m(\pi_t) = r_t(\pi_t)\ \forall\ \pi_t \leq \pi_t^*$, while $r_t^m(\pi_t) < r_t(\pi_t)$ for $\pi_t > \pi_t^*$. Thus in a panic those agents needing liquidity (movers) suffer relative to agents who do not (non-movers). This could be regarded as a disruption of the transactions process. Notice also that banks

respond optimally to this "disruption," treating all movers alike. In particular there is no "sequential service" constraint in effect, of the type discussed in Diamond–Dybvig (1983) or Wallace (1988, 1989).

Using the definition of π_t^* in (13), we note that the bank's optimal reserve liquidation strategy [equation (11)] can be written as

$$(11') \quad \alpha_t(\pi_t) = \min[\pi_t/\pi_t^*, 1].$$

We can also succinctly characterize the optimal choice of the reserve–deposit ratio. In particular, define the function H_t: $[0, 1] \to [0, 1]$; $t = o, e$, by

$$H_t(x) = \int_x^1 F_t(\pi)\, d\pi .$$

Then (12) can be written as

$$(14) \quad 1 - \gamma_t = H_t[g(\gamma_t, I_t)]; \quad t = o, e.$$

Equation (14) is depicted diagrammatically in Figure 1. It is easy to show that $H_t[g(\gamma, I)]$ is a decreasing function of γ, and is concave in γ if $I \geq 1$. In addition, $H_t[g(0, I)] = H_t(0) < 1$, and $H_t[g(1, I)] = H_t(1) = 0$, $\forall I$. Finally, the slope of $H_t[g(\gamma, I)]$ exceeds one in absolute value at $\gamma = 1$ $\forall I > 1$, and is equal to one in absolute value if $I = 1$. It follows that, if $I_t = 1$, (14) is satisfied only by $\gamma_t = 1$. If $I_t > 1$ holds (the nominal interest rate is positive), then (14) has two solutions. It is easy to check that the interior solution solves the bank's problem.

From (13) and the definition of $H_t(\cdot)$, it is evident that an increase in I shifts $H_t[g(\gamma, I)]$ upwards, as depicted in Figure 1. Then apparently the optimal choice of γ_t, as defined by (14), is decreasing in I_t. We summarize these results by saying that the optimal reserve–deposit ratio is given by $\gamma_t = \gamma_t(I_t)$; with $\gamma_t(1) = 0$ and $\gamma_t' < 0$; $t = o, e$.

2.2. *General Equilibrium*

We now describe the complete general equilibrium of this economy when note issues are prohibited. We note first that, in equilibrium, loans must be made in positive quantities. Then, since $\gamma_t(1) = 1$, it follows that $I_t > 1$ must hold $\forall\ t$, or in other words, in equilibrium nominal interest rates are always positive.

As in section 1.4, it continues to be the case that, in equilibrium, net generational savings equals real balances, and that all real balances are held as cash reserves by banks. Then (5) and (6) continue to hold. However now γ_t satisfies (14), so (5), (6), and (14) are the equilibrium conditions of this economy. As before, we confine attention to periodic equilibria satisfying $R_t = R_i$, $p_t = p_i$, and $\gamma_t = \gamma_i\ \ \forall\ t$, where $i = o$ for t odd and $i = e$ for t even.

In order to characterize such equilibria, we can use (5) and (6) to eliminate $R_t p_t / p_{t+1}$ from (13), obtaining

$$(15) \qquad \pi_o^* = \beta x \gamma_e / (\beta x \gamma_e + y_o),$$

$$(16) \qquad \pi_e^* = \beta x \gamma_o / (\beta x \gamma_o + y_e).$$

Then, using (15), (16), and $\pi_t^* = g(\gamma_t, I_t)$ in (14) yields

$$(17) \qquad 1 - \gamma_o = H_o[\beta x \gamma_e / (\beta x \gamma_e + y_o)],$$

$$(18) \qquad 1 - \gamma_e = H_e[\beta x \gamma_o / (\beta x \gamma_o + y_e)].$$

Here, (17) and (18) determine the equilibrium levels of γ_o and γ_e.

Proposition 1. (a) Equations (17) and (18) have a unique solution (γ_e^*, γ_o^*). This solution satisfies $1 > \gamma_t^* > 0$; $t = e, o$. (b) $y_o \gamma_o^* > y_e \gamma_e^*$ holds.

The proof appears in Appendix A.

This economy, then, has a unique periodic equilibrium. Panics occur in this equilibrium if and only if $\pi_t > \pi_t^*$, which corresponds to a situation in which banks exhaust their reserves. The

equilibrium values π_t^* are obtained by substituting γ_e^* and γ_o^* into (15) and (16). Part (b) of the proposition implies that $\pi_o^* < \pi_e^*$. Thus panics occur whenever withdrawal demand exceeds a critical level. This critical level is lowest in periods of greatest seasonal pressure on financial markets. Therefore, as argued by Andrew, Sprague, and Goodhart, smaller shocks are required to cause a panic in periods when the most seasonal pressure is placed on the banking system. The probability of a panic at t is $1 - F_t(\pi_t^*)$. Then since $\pi_e^* > \pi_o^*$ and $F_o \geq F_e$ in the sense of first–order stochastic dominance, panics are also most probable in periods of peak seasonal pressures.

Perhaps not surprisingly, it is the case that $\gamma_e^* \gtreqless \gamma_o^*$ can hold. If $\gamma_o^* < \gamma_e^*$, banks hold least reserves at the time heavy withdrawals are most likely. Sprague (1910) argues that this was in fact observed behavior, although in contrast to what Sprague clearly implies, this does not indicate that banks were ignoring the probability of heavy withdrawal demand. If $\gamma_e^* < \gamma_o^*$, reserves are highest in periods when large withdrawals are most likely. The result $\gamma_e^* \leq \gamma_o^*$ will obtain if $y_o - y_e$ is sufficiently small, given $F_o(\cdot)$ and $F_e(\cdot)$, while $\gamma_o^* > \gamma_e^*$ will hold if max $|F_e(\pi) - F_o(\pi)|$ is sufficiently small, given $y_o > y_e$.

Again, having obtained γ_o^* and γ_e^*, the equilibrium inverse price level p_o^* and p_e^* are given by (6). Apparently, if $\gamma_o^* \geq \gamma_e^*$, $p_o^* \geq p_e^*$. Thus restrictions on note issues can actually reverse the seasonal pattern of prices relative to the elastic currency regime.

It is also of interest to consider the seasonal patterns of nominal and real interest rates.

Proposition 2. $I_o^* > I_e^*$ and $R_o^* > R_e^*$ hold, where a "*" denotes an equilibrium level under the inelastic currency regime.

The proof of Proposition 2 appears in the appendix. Proposition 2 asserts that currency inelasticity will allow seasonal pressures on financial markets to be reflected in seasonal variations in nominal interest rates. This is consistent with Lockhart's (1921a, p. 160) argument that "our rigid reserve system and our inelastic bank note currency were... the principal reasons" for the relatively large historical fluctuations in nominal interest rates.

Proposition 2 and the fact that $1 - F_o(\pi_o^*) > 1 - F_e(\pi_e^*)$ imply that high nominal interest rates reflect a high probability of a panic. Positive nominal interest rates also indicate that the equilib-

rium obtained here cannot be Pareto optimal (since reserves are free to create, but agents perceive a positive opportunity cost to holding them). The possibility of panics and lack of Pareto optimality indicates that the inelastic currency regime has few desirable characteristics. However, we should note that the equilibria of the elastic and inelastic currency regimes are not Pareto comparable, so that there are "winners" under the inelastic currency regime.

2.3. *Currency Premia and Panics*

One possibility that we have thus far implicitly ignored is that, at some date t, a young lender could accumulate currency (which they do not deposit) as a hedge against the event of being a "mover." In the event that he is a "nonmover" this cash could be offered to other movers in exchange for claims to their bank deposits. If $\pi_t \leq \pi_t^*$, $r_t^m(\pi_t) = r_t(\pi_t)$ holds, and since nominal interest rates are positive this strategy will involve a loss. However, if $\pi_t > \pi_t^*$, $r_t^m(\pi_t) < r_t(\pi_t)$ holds, and one can imagine that a "currency premium" might emerge in which currency is worth more than deposits having an equal face value. We now compute an implicit currency premium, and show that, in equilibrium, the quantity of currency traded in this way will be zero.

Let $q_t(\pi_t)$ denote the real quantity that must be paid for one unit of real balances at t after the state π_t has been observed. The object used to acquire real balances is a (partial) claim to the purchaser's deposits. If $q_t(\pi_t) = \max\,[1, \pi_t/\gamma_t^*]$ then it is straightforward to verify that (a) the equilibrium quantity of currency held by young agents for "speculation" of this type is zero, and (b) movers are content with zero exchanges of deposit claims for currency. Thus $q_t(\pi_t) = \max\,[1, \pi_t/\gamma_t^*]$. Since it is easy to show that $\gamma_t^* > \pi_t^*$, a positive currency premium arises only in the event of a panic, and in fact, only if the panic is sufficiently severe (withdrawal demand is sufficiently high).

Currency premia, were, in fact, important observed features of panics, as discussed by Sprague (1910, pp. 56–7, 187) and Andrew (1908a, pp. 292–3). And, as this discussion indicates, if agents in the model could produce currency substitutes during panics they clearly would. In practice, of course, the creation of currency substitutes during panics was often substantial [Andrew (1908b), Friedman–Schwartz (1963)].

[Parenthetically, this distinguishes our model from that of Wallace (1989). Wallace (1989) points out that in his model the creation of emergency currency could not have been of value in a panic. We return to this point below.]

Finally, we note that our results on currency premia rely on the assumption that lenders and borrowers do not meet. If they did meet after π_t was realized at t, borrowers could easily have an incentive to borrow and acquire currency, which would be sold to movers if a currency premium arose. Since this would be relatively intractable, and would also be tangential to the main issues of interest to us, we chose to rule out this possibility. Obviously the easiest way to do so is to assume that lenders and borrowers are never in contact. An alternative way to rule this out would be to impose additional restrictions on the density functions $f_t(\cdot)$.[14]

2.4. *Remarks*

Panics in this model occur purely because of the exhaustion of bank reserves. Sprague (1910a, p. 222) asserts that, at least in the panic of 1873, suspension occurred in New York not because of any perception of insolvency of the banks, but exactly because of the threatened exhaustion of their reserves. Thus our description seems to capture a real historical phenomenon.

The adverse consequences of panics in our model derive entirely from the fact that they disrupt inter–location exchange. Sprague (1910, p. 200) claims that in 1893 suspensions "deranged the exchanges between different parts of the country," and also argues (p. 71) that if trade were "purely local" in nature, suspension would have had only minor consequences, as in this case transactions could have been accomplished with checks or other "local" currency substitutes. [This point is reinforced by the discussions in Andrew (1908b), see especially p. 515, and Lockhart (1921b, pp. 228, 233–4).] Again this seems consistent with our description.

Of course panics in this model are in some sense simply a symptom of the larger problems caused by currency inelasticity. These problems are reflected in the presence of a positive nominal interest rate, which is indicative of a permanent inefficiency. Interestingly, this appears to have been Laughlin's (1912, p. 129) view of the National Banking System: "it is probable that the evils experienced from this unsatisfactory bank currency in periods of panic are not nearly as great as those

which result from the unsatisfactory working of the system year in and year out." This also appears in our analysis.

As a final remark, we note that panics, as well as the problems just described, arise in our model because a prohibition on note issues interferes with liquidity provision by banks. A natural question, then, is why other financial market arrangements did not arise to circumvent the problem of an inelastic currency? While anything other than a speculative answer is beyond the scope of this paper, Davis (1965) provides a suggestion that a broad array of legal restrictions inhibited the development of nationally integrated financial markets in the U.S. Thus the same factors interfering with the operation of the banking system had more general implications for financial markets more broadly defined.

2.5. *Empirical Implications*

Some empirical implications of the model have already been derived. First, panics are most likely in periods of greatest seasonal pressure on financial markets. That this is observed in the data is a major theme of Sprague (1910) and Goodhart (1969). Second, nominal interest rates will vary seasonally, being highest in periods of seasonal pressures. To derive further implications we proceed as in section 1.5, and derive expressions for end-of-period values for currency *in circulation*, reserves, loans, and deposits, all in nominal terms.

With respect to reserves, end-of-period bank reserves are just beginning-of-period reserves (M), less liquidated reserves $[\alpha_t(\pi_t)M]$. Therefore nominal end-of-period bank reserves are given by

$$K_t(\pi_t) = [1 - \alpha_t(\pi_t)]M = \begin{cases} M(1 - \pi_t/\pi_t^*) & \pi_t < \pi_t^* \\ 0 & \pi_t \geq \pi_t^* \end{cases}$$

Since $\pi_e^* > \pi_o^*$, end-of-period reserves will be no higher in odd than in even periods for any value of π_t, and will be strictly lower for some π_t. Thus average reserves will be lowest in periods when seasonal demands on the banking system are greatest. Furthermore since currency *in circulation* at t is

just $\alpha_t(\pi_t)M = M - K_t(\pi_t)$, the average stock of currency in circulation will be greatest in odd periods.

With respect to deposits, the end–of–period nominal value of deposits is simply the beginning–of–period nominal value $[\beta x/(1+\beta)p_t]$ less withdrawals $[\alpha_t(\pi_t)M]$. Thus, if D_t is end–of–period deposits at t,

$$D_t(\pi_t) = \begin{cases} \beta x/(1+\beta)p_t - M\pi_t/\pi_t^* & \pi_t \le \pi_t^* \\ \beta x/(1+\beta)p_t - M & \pi_t \ge \pi_t^* \end{cases}$$

If $p_o^* \ge p_e^*$, then $D_o(\pi_t) \le D_e(\pi_t)$, $\forall\ \pi_t$, and deposits will be smallest (state–by–state) in odd periods. If $p_e^* > p_o^*$ this conclusion need not hold.

It is also of some interest to consider the end of period reserve–deposit and currency–deposit ratios. The reserve–deposit ratio is $K_t(\pi_t)/D_t(\pi_t)$ at t, which will attain its minimum when $\pi_t \ge \pi_t^*$ (during panics). The currency–deposit ratio if $\pi_t < \pi_t^*$ (a panic does not occur) is given by

$$[M - K_t(\pi_t)]/D_t(\pi_t) = \pi_t\gamma_t^*/(\pi_t^* - \pi_t\gamma_t^*).$$

In the event of a panic ($\pi_t \ge \pi_t^*$), the currency–deposit ratio is

$$[M - K_t(\pi_t)]/D_e(\pi_t) = \gamma_t^*/(1 - \gamma_t^*).$$

Since $\pi_t\gamma_t^*/(\pi_t^* - \pi_t\gamma_t^*) < \gamma_t^*/(1 - \gamma_t^*)$, the currency–deposit ratio will be highest during panics. As noted by Friedman–Schwartz (1963), this is in fact true historically. Indeed an outside observer, armed only with observations on monetary aggregates and a knowledge of when panics occured, might be tempted to conclude that a panic occurs when the currency–deposit ratio exceeds a critical value. Of course in the model a causal interpretation along these lines would not be warranted.

Finally, nominal loans in the model are just nominal deposits less nominal reserves, which as before is given by $\beta x/(1+\beta)p_t - M = L_t$. Then $L_o > L_e$ if and only if $p_o^* < p_e^*$ ($\gamma_e^* > \gamma_o^*$). This seems to correspond to what Sprague (1910) claimed was true historically. However, if $p_o^* \ge p_e^*$, then $L_o \le L_e$ can hold.

3. Comparison of the Two Regimes

3.1. *Policy Aspects*

We have seen that an elastic currency regime supports a Pareto optimal equilibrium in which panics are avoided. An inelastic currency regime must have $I_t > 0 \; \forall \; t$, and hence cannot support an optimal equilibrium. Moreover, it permits panics to occur.

There was some reason for the organizers of the National Banking System to believe that adequate incentives were provided within it to achieve a reasonable degree of currency elasticity. (See Champ 1990 for an argument to this effect.) However, by the late 1800s there was substantial agreement that this was not the case. West (1977, pp. 43–5) asserts that "after 1893 the business and financial community was nearly unanimous in its desire to abolish bond–secured currency and issue a new national banknote secured by the assets of the issuing bank," and describes several proposals to create an "asset currency" along Canadian lines.[15] Many of the ingredients of such proposals were incorporated into the Aldrich–Vreeland Act (which permitted "emergency" note issues against general assets), and ultimately in the Federal Reserve Act. Interestingly, Friedman–Schwartz (1963, p. 172) argue that in 1914 "the Aldrich–Vreeland Act provided an effective device for solving a threatened interconvertibility crisis...." This is consistent with the implications of our model, but is far from consistent with the implications of other panic models. Wallace (1990), for instance, points out that in his model the Aldrich–Vreeland Act could not avert panics or suspensions.

Our elastic currency (or "real–bills") regime has a number of attractive properties, then. However our analysis is also suggestive that the primary historical criticism of such regimes has some merit. More specifically, the standard criticism of real–bills regimes is that they permit "excessive" fluctuations in prices and the inside money stock, and possibly indeterminacies in these dimensions. While we have not pursued this formally, the observation in section 1.3 that banks are indifferent regarding the level of note redemptions is suggestive that there may be an indeterminacy/coordination problem regarding note issues. In fact, this feature is somewhat reminiscent of the model in Shell (1977), where sunspot equilibria are easily constructed.

While we leave a formal investigation of this issue as a topic for future research, we note that historical real–bills advocates were quite concerned with it. Laughlin (1912) devotes an entire chapter to the issue of how to ensure rapid note redemption, concluding (p. 159) that "elasticity in extending notes and credit in time of need must always be accompanied by proper regulations for their contraction when the need has passed by." Laughlin also offered several proposals along these lines. Since relatively prompt note redemption appears to have been achieved in Canada, it seems probable that these represent surmountable problems.

3.2. *Empirical Aspects*

We now contrast the predictions of our model with monthly banking (and interest rate) data over the period 1880–1910 (1902–1914) for the U.S. and Canada. Implicit in our approach is the assumption that the U.S. and Canada were essentially identical (in per capita terms) economically, except for the differences in their banking systems, and that they experienced the same underlying disturbances. All banking data (that appears in levels) is in nominal terms, as there are no adequate monthly price indices. The Canadian data is quite comprehensive, consisting of monthly balance sheet data for all chartered banks. Except for national bank circulation (which is comprehensive), the U.S. banking data is for New York Clearinghouse banks only.[16] Interest rates are call loan rates in New York and Montreal. (A complete description of the data appears in Appendix B.)

For each time series we performed the decomposition $x_t = x_t^T + x_t^S + x_t^B$, where x_t is the natural logarithm of the raw series, and x_t^T, x_t^S, and x_t^B are trend, seasonal, and cyclical components, respectively. The decomposition obtained x_t^T by use of a Hodrick–Prescott filter.[17] The remaining percentage deviations from trend were regressed on monthly dummies to obtain x_t^S, and x_t^B constitutes the residual. We are now interested in examining the behavior of the seasonal and cyclical components of these series. We note that in doing so for the seasonal component of the U.S. time series we are simply reproducing results in Watkins (1929) and Miron (1986); however neither of these authors examines Canadian data.

As we discussed, seasonal changes in odd periods in the model are intended to capture recurring seasonal pressures on financial markets created by higher than average demands for credit

and liquidity during the autumn crop–moving season. The model predicts that, for Canada (the elastic currency regime), currency circulation should be high during the fall. Indeed, this prediction is borne out in Figure 3, which indicates considerable seasonal elasticity in the stock of banknotes in circulation, with a peak in the autumn months. (A similar seasonal pattern appears in dominion notes, which we do not depict here.) Correspondingly, as is consistent with the model, Figure 3 indicates almost no seasonal variation in U.S. national banknote circulation.

The model also predicts that Canada should display no seasonal variation in nominal interest rates, while there should be seasonal variation in these rates in the U.S. (with nominal rates being highest in the fall). Figure 4 indicates that these predictions are supported by the data. Here, however, we should offer two caveats. First, the predictions of the model literally concern time loans, while the data constitute call loan rates. Since no other interest rate data is available for Canada, there appears to be no superior method for confronting the predictions of the model with the data. Second, there are some grounds to doubt the comparability of the New York and Montreal call loan markets, since Montreal was a far less important financial center than New York. And indeed, there was less seasonal variation in call loan rates in other U.S. cities than there was in New York (Goodhart 1969, pp. 88–91). However, according to Rich (1989), call loan rates in Montreal show less seasonal variation than call loan rates in Chicago or Boston, confirming the predictions of the model.

The model makes no explicit predictions about the behavior of bank reserves in Canada, although it is consistent with little or no seasonal variation in them. However, for the inelastic currency regime (the U.S.) the model predicts that reserves will (on average) be low in the fall. As indicated in Figure 5, this is consistent with observation. Notice that the seasonal volatility of U.S. reserves is much greater than that in Canada, with reserves falling more than 6% below average in the autumn. Canadian reserves tend to rise slightly in the fall. Figure 6 shows that similar patterns are observed in the behavior of the reserve–deposit ratio.

For Canada, the model predicts that nominal loans should be higher than average in the autumn months, but that the seasonal pattern in nominal deposits depends on the relative importance of credit and liquidity shocks. Figures 7 and 8 indicate relatively a small amount of seasonal variation in both loans and deposits in Canada, with seasonal deviations from trend of at most slightly more than

1%. In Figure 7, there is a peak in loans in the fall, but loans are also high on average in the spring and early summer. In the U.S., there is more seasonal variation in nominal loans and deposits than in Canada, with both being low on average in the fall. In the model, this is consistent with a liquidity shock in the fall which is large relative to the shock to credit demand.

Figures 9–18 plot the business cycle components for all the quantity data. Banking panics occurred during 1884, 1893, and 1907 in the United States (Sprague 1910). With this sample of three, one panic occurred in mid–year (1884), while the 1893 and 1907 panics were in the autumn, when the model predicts that the probability of a panic is highest. Panics show up most clearly in the business cycle component of U.S. bank reserves (Figure 12).

Under the assumption that the U.S. and Canada are subject to the same shocks, we should observe large quantities of banknotes in circulation in Canada coincident with panics in the United States, given that banknote issues in Canada accommodate liquidity shocks. In Figure 9, the business cycle component of Canadian banknotes in circulation is below trend during the 1884 panic, but above trend during the panics of 1893 and 1907. Banknote circulation in the U.S. also rises in the vicinity of the panics of 1893 and 1907, but the peak note issues actually occur one or two months after the panics, and two or months later than peak note issues in Canada. This is consistent with the arguments of Laughlin (1912) and Carlisle (1894) that the mechanism for issuing notes in the U.S. prevented them from being useful in panics. Note also, in Figures 9 and 10, that there is much more high frequency variation in Canadian banknote circulation than in national banknotes, consistent with a greater sensitivity of the currency stock in Canada to financial shocks.

The business cycle components of reserves in New York City and the reserve ratio (Figures 12 and 16) show a marked difference from those in Canada (Figures 11 and 15). During all three panic periods, there were very large declines in New York in both the quantity of reserves and the reserve ratio. The declines in reserves are from 25% to 55% below trend during the three panics. However, in Canada there are no unusual deviations from trend in either reserves or the reserve ratio during U.S. panic periods. Note that deviations in the Canadian reserve ratio from trend are at most slightly greater than 2% (Figure 15), while the largest deviation in New York is more than 10% from trend. This behavior of reserves is consistent with the model's predictions.

In Figures 13 and 14, the business cycle components of nominal deposits in Canada and the United States are plotted. The relative behavior here is similar to that of reserves. U.S. deposits display more volatility than deposits in Canada, and there are precipitous declines in deposits during the 1884 and 1893 panics in the United States. The absence of a significant decline in deposits in the U.S. during the 1907 panic is explained by the relatively early suspension of convertibility at that date. Deposit declines in Canada do not appear to be directly related to any of the U.S. panic dates, though relatively large declines occur following the 1884 and 1907 panics. These decreases in deposits are much smaller, in terms of percentage deviations from trend, than the declines which occurred in the United States during the 1884 and 1893 panics.

As for loans, the plots of the business cycle components of loans in Canada and the United States (Figures 17 and 18, respectively) show less average volatility in Canada than in the United States. In the U.S., loans either decline precipitously (1884 and 1893) at panic dates, or are below trend (1907). Loans in Canada are actually above trend in 1893 and 1907. Thus, in marked contrast to their U.S. counterparts, Canadian banks followed Bagehot's (1876) dictum of lending freely under panic conditions.

The data we have examined tend to support the predictions of the model we have constructed and analyzed. The behavior of U.S. and Canadian banking and financial data for this period differs dramatically, and in ways which are consistent with an elastic currency system in Canada and an inelastic currency system in the United States.

4. Some Comments on the "Seasonal Plus Shock" View of Panics

The following view of panics, which can be attributed to Andrew, Sprague, and others, has found wide acceptance and has considerable intuitive appeal:

> Financial crises and seasonal variations were not considered to be separate phenomena. Financial crises were attributed, with a great deal of truth, not so much to cyclical factors as to the natural results of the recurring autumnal pressures upon the money market; ... it took only a little extra strain... to turn tightness into distress (Goodhart 1969, p. 3).

More specifically, according to the "seasonal plus shock" notion, there were large autumnal pressures on New York banks to ship cash to the interior for "crop–moving" purposes. This recurring

strain, augmented by even relatively minor additional shocks to withdrawal demand, could cause a shortage of liquidity and suspension of convertibility by New York banks.

Criticisms of the "seasonal plus shock" view appear in Patterson (1913), Goodhart (1969), and Calomiris–Gorton (1990). There it is argued that, even though New York banks shipped cash to the interior in the fall, interior banks shipped cash back in the form of direct lending in New York. Thus the liquidity position of New York was not seriously impaired. Patterson (1913, pp. 524–6) and Goodhart (1969, pp. 5, 7, 89, 102–3) argue that loans made directly "on account of correspondents increased enough to more than offset the flow of bankers' balances to the interior." Thus the argument is that net interregional funds flows were not unusually large in the fall. Calomiris–Gorton (1990), while not being so specific about mechanisms, point out that net interregional funds flows were not abnormally large prior to panics.

Our analysis is very much a formal depiction of the "seasonal plus shock" theory of panics. However, notice that the symmetric nature of locations in our model implies that, in the model, net inter–location funds flows are *always zero*. What is actually relevant in the model is the gross flow of funds between regions. Thus the analysis indicates that the "seasonal plus shock" view can easily be valid, even though net flows of funds from New York to the interior do not appear to be observed.

5. Conclusions

This paper develops a model of bank liquidity provision in which there are both store of value and medium of exchange roles for currency.[18] In addition, seasonal factors affecting credit and liquidity demand have been introduced. The result is a model in which the regulatory regime matters greatly for the possibility of panics, the existence of an optimal equilibrium, and possibly for determinacy of equilibrium as well. Moreover, under either an elastic or an inelastic currency regime, the model generates predictions about both the seasonal and cyclical behavior of banknote circulation, nominal interest rates, loans, deposits, bank reserves, and the reserve–deposit and currency–deposit ratios. A preliminary investigation indicates that these predictions accord well with historical observation. The model also makes predictions about currency premia and the potential role for "emergency" cur-

rency substitutes during panics that appear to be borne out by observation. Thus the model permits a reintroduction of monetary factors into a discussion of bank panics in a way that seems empirically plausible.

There are, of course, a number of issues that deserve to be pursued further or that we have abstracted from that we mention as possible future extensions of this work. One would involve a formal treatment of the coordination/indeterminacy problems that appear possible under an elastic currency regime. This topic merits further investigation since it involves the main criticism of "real–bills" regimes.

Second, while we have abstracted from any other differences in the organizational structures of the U.S. and Canadian banking systems in order to focus on the issue of currency elasticity, this does not imply that we regard these differences as unimportant. It would be of interest to consider the issues addressed here in a model that captures other differences between the two systems. Two obvious candidates would be different branching restrictions, and differences in reserve requirements (see Williamson 1989 for some discussion of these differences). One issue that would obviously arise would be the desirability of a Canadian–like "asset currency" system in the U.S., where the number of banks was vastly larger and the degree of coordination between banks much lower than in Canada. Obviously this would exacerbate any coordination problems inherent in the elastic currency regime, and possibly add informational problems regarding the note issues made by large numbers of small banks. In fact, Sprague (1910 a, b, c) argued that the introduction of an asset currency in the U.S. could have significant beneficial effects only if a number of other aspects of the banking system were reformed as well. A formal treatment of these issues would be an interesting topic for further research.[19]

A third extension would involve the issues addressed here while treating Canada and the U.S. as open economies that interact. In particular, we have treated Canada and the U.S. as two closed economies. While this is consistent with standard practice (see Noyes 1909 and Rich 1989), it obviously is not ultimately defensible. Moreover, as Rich (1989) shows, Canadian banks were indirectly (although not directly—see Ross 1922) large lenders to the U.S. both seasonally, and during

panics. It would be interesting to consider a model that permits interaction between an economy with an elastic currency and one with an inelastic currency.

Another possible extension would be to compare the behavior of the U.S. and Canadian systems with an activist central bank present in the U.S. system. Assuming central bank behavior consistent with that of the Federal Reserve in the late 1920s and early 1930s would allow the model to be used to confront observations from the Great Depression. Since the U.S. and Canadian systems again seem to behave quite differently (compare Bernanke 1983 with Haubrich 1990), it would be interesting to see to what extent this could be explained by difference in currency elasticity. Also, since industrial production data would then be available for Canada, there would be a point to theoretical consideration of a production economy. This would permit a theoretical and empirical treatment of how the currency system affects the behavior of real activity.

Finally, we have not allowed for the possibility that banks actually fail. While very low actual depositor loss rates in both the U.S. and Canada in the period we examine (see Sprague 1910, Gorton 1988, and Williamson 1989) makes this a reasonable first approximation, depositor loss rates in Canada were significantly lower in percentage terms than those in the U.S. (Williamson 1989). It would be interesting to allow features that would permit banks to fail, and see how bank failures are affected by the currency regime.

Appendix A

<u>Proof of Proposition 1</u>

***Lemma* 1.** Equations (17) and (18) have a solution (γ_e^*, γ_o^*) with $\gamma_t^* \in (0,1)$ for $t = e, o$.

Proof: Consider Figure 2. Clearly (17) and (18) define continuous loci in the figure. The locus defined by (17) passes through the point $(1 - H_o(0), 0)$, and clearly $1 > H_o(0) > 0$. It also passes through the point $(1 - H_o[\beta x/(\beta x + y_o)], 1)$. The locus defined by (18) passes through the points $(0, 1 - H_e(0))$, with $1 > H_e(0) > 0$, and $(1, 1 - H_e[\beta x/(\beta x + y_e)])$. Then (17) and (18) define loci as shown, which clearly deliver a solution with the desired property. ❑

***Lemma* 2.** $1 - x \geq H_t(x) \geq F_t(x)(1 - x)$ for all $x \in [0, 1]$, $t = e, o$.

Proof: Obvious from the definition of $H_t(\cdot)$.

***Lemma* 3.** In (17), $d\gamma_e/d\gamma_o \geq \gamma_e/\gamma_o(1 - \gamma_o)$.

Proof: Differentiating (17) gives

$$\text{(A.1)} \qquad d\gamma_e/d\gamma_o = -(\beta x\gamma_e + y_o)^2/\beta x y_o H_o'[\beta x\gamma_e/(\beta x\gamma_e + y_o)]$$
$$= (\beta x\gamma_e + y_o)^2/\beta x y_o F_o[\beta x\gamma_e/(\beta x\gamma_e + y_o)].$$

Furthermore, from (17) and Lemma 2,

$$1 - \gamma_o \geq F_o[\beta x\gamma_e/(\beta x\gamma_e + y_o)]y_o/(\beta x\gamma_e + y_o).$$

Using this in (A.1) gives

$$\text{(A.2)} \qquad d\gamma_e/d\gamma_o \geq (\beta x\gamma_e + y_o)/\beta x(1 - \gamma_o).$$

If we apply the remainder of Lemma 2 to (17) we have $1 - \gamma_o \leq y_o/(\beta x\gamma_e + y_o)$, or equivalently, $\gamma_o \geq \beta x\gamma_e/(\beta x\gamma_e + y_o)$. Substituting this into (A.2) gives the desired result. ❑

***Lemma* 4.** From (18), $d\gamma_e/d\gamma_o \leq \gamma_e(1 - \gamma_e)/\gamma_o$.

Proof: Differentiating (18) gives

$$\text{(A.3)} \qquad d\gamma_e/d\gamma_o = -H'_e[\beta x\gamma_o/(\beta x\gamma_o + y_e)]\beta x y_e/(\beta x\gamma_o + y_e)^2$$
$$= F_e[\beta x\gamma_o/(\beta x\gamma_o + y_e)]\beta x y_e/(\beta x\gamma_o + y_e)^2$$

Now from (18) and Lemma 2,

$$1 - \gamma_e \geq F_e[\beta x\gamma_o/(\beta x\gamma_o + y_e)]y_e/(\beta x\gamma_o + y_e).$$

Using this in (A.3), we obtain

$$\text{(A.4)} \qquad d\gamma_e/d\gamma_o \leq \beta x(1 - \gamma_e)/(\beta x\gamma_o + y_e).$$

Also applying Lemma 2 to (8) again implies that $1 - \gamma_e \leq y_e/(\beta x\gamma_o + y_e)$, or equivalently $\gamma_e \geq \beta x\gamma_o/(\beta x\gamma_o + y_e)$. Substituting this into (A.4) gives the desired result. ❑

***Lemma* 5.** Equations (17) and (18) have a unique solution with $\gamma_t^* \in [0, 1]$, $t = e, o$.

Proof: Immediate from Lemmas 1, 3, and 4. ❑

***Lemma* 6.** $y_e\gamma_e^* < y_o\gamma_o^*$.

Proof: Suppose to the contrary that $y_e\gamma_e^* \geq y_o\gamma_o^*$. Then from (17) and (18),

$$\text{(A.5)} \qquad y_o - y_e \leq y_o H_o[\beta x\gamma_e/(\beta x\gamma_e + y_o)] - y_e H_e[\beta x\gamma_o/(\beta x\gamma_o + y_e)]$$
$$\leq y_o H_o[\beta x\gamma_e/(\beta x\gamma_e + y_o)] - y_e H_o[\beta x\gamma_o/(\beta x\gamma_o + y_e)]$$
$$\leq (y_o - y_e)H_o[\beta x\gamma_o/(\beta x\gamma_o + y_e)],$$

where the second inequality follows from $H_e(z) \geq H_o(z)$ for all z, and the third inequality follows from the hypothesis of the Lemma and $H'_o < 0$. But since $H_o(z) < 1$ for all z, (A.5) is a contradiction. ❑

<u>Proof of Proposition 2</u>

We consider two possible cases.

<u>Case 1</u>: $\gamma_o^* \geq \gamma_e^*$. From equations (5) and (6), it follows that

(A.6) $\quad R_t^* = y_t/\beta x(1-\gamma_t^*)\,; \quad t = o, e.$

Therefore $R_o^* > R_e^*$. Moreover, in this case $p_o^* \geq p_e^*$. Then clearly $I_o^* = R_o^* p_o^*/p_e^* > R_e^* p_e^*/p_o^* = I_e^*$.

<u>Case 2</u>: $\gamma_e^* > \gamma_o^*$. In this case we first prove by contradiction that $I_o^* > I_e^*$. Then, since $\gamma_e^* > \gamma_o^*$ implies that $p_o^* < p_e^*$, it clearly follows that $R_o^* > R_e^*$.

Then, suppose, by way of deriving a contradiction, that $I_e^* \geq I_o^*$. It follows from equation (14), $H_e[g(\gamma, I)] \geq H_o[g(\gamma, I)]$, $\forall\ \gamma, I$, and the observations in the text regarding Figure 1 that $\gamma_e^* \leq \gamma_o^*$. But this is the desired contradiction. ❑

Appendix B

Description of the Data

The sources for the data analyzed in this paper are detailed below. All data are end–of–month observations, except call loan rates which are monthly averages. Complete citations follow in the Reference section. The transformations of this raw data are described in the paper.

Canadian Series	Source	Description
Banknote circulation	Breckenridge (1910, Appendix VI, p. 290)	Banknote circulation of Canadian chartered banks
Call loan rate	Goodhart (1969, Table 14, pp. 206–20)	Montreal call loan rate
Cash reserves	Curtis (1931, pp. 36 and 38)	Sum of gold, subsidiary coin, and Dominion notes held by chartered banks
Reserve ratio	Calculated	Cash reserves/Deposits
Loans	Curtis (1931, p. 50)	Total loans in Canada
Deposits	Curtis (1931, pp. 24–26)	Sum of total deposits by the public, provincial government deposits, and Dominion government deposits

U.S. Series	Source	Description
Banknote circulation	National Monetary Commission (1909, Table 19)	Banknote circulation of U.S. National Banks
Call loan rate	Goodhart (1969, Table 14, pp. 206–20)	New York City call loan rate
Cash reserves	National Monetary Commission (1909, Table 28)	Specie and legal tender notes held by New York City Clearinghouse banks
Reserve ratio	Calculated	Cash reserves/Deposits
Loans	National Monetary Commission (1909, Table 28)	Loans of New York City Clearinghouse banks
Deposits	National Monetary Commission (1909, Table 28)	Net deposits of New York City Clearinghouse banks

All New York City Clearinghouse bank series are monthly averages of the original weekly data. The timing convention for the determination of months followed that of Kemmerer (1910, p. 13).

Notes

[1]The closest event to a U.S. style panic in Canadian history appears to have occurred in 1837–38 during a period of political unrest. For an account see Redish (1983).

[2]Other important theoretical contributions that we would like to at least briefly acknowledge include Gorton (1985), Bhattacharya–Gale (1987), Bental–Eckstein–Peled (1989), Calomiris–Kahn (1989), and Donaldson (1988). All of them present real economies.

[3]As will be apparent, the exact specification of endowment patterns and population proportions is without loss of generality. Also, we note that the environment, to this point, is a special case of that described in Sargent–Wallace (1982).

[4]For corroboration or even stronger assertions on this point see Stevens (1894, p. 140), Laughlin (1912, p. 323), Goodhart (1969, p. 6), or Rich (1989, p. 150), who also makes clear that the same situation existed in Canada.

[5]Note that R_t is not contingent on π_t. When banks are note issuing this lack of state contingency is innocuous. When banks are not note issuing it is not; however lack of state contingency could be motivated by observing that borrowers are physically separated from lenders when π_t is realized. Borrowers therefore do not observe π_t, making it natural not to condition repayments on it. A lack of state–contingency in loan rates also has a certain amount of historical realism, since usury laws probably prevented a certain amount of variation in loan rates [as argued in Sprague (1910, p.) and West (1977, p. 39)].

[6]The presence of the term p_t/p_{t+1} reflects the fact that the bank gives currency or notes to movers at t. These earn the real rate of return p_{t+1}/p_t between t and $t+1$. Thus a payment of $r_t^m(\pi_t)p_t/p_{t+1}$ to movers at t results in a perceived return to the mover of $r_t^m(\pi_t)$.

[7]The specification of the model where there is a completely illiquid asset and a liquid asset held as a reserve by the bank obviously resembles Jacklin and Bhattacharya (1988).

[8]The assumption of logarithmic utility implies that the solution to this problem would be unaffected if banks did *not* take depositor behavior as given (i.e., if they viewed themselves as being able to choose d_t as well as return schedules.

[9]Banknotes can be redeemed across locations when relocations occur, at which point the two locations are in contact and liabilities can be transferred between them.

[10]In fact the equilibrium derived above is identical to that in Sargent–Wallace (1982) when the number of their "poor savers" is zero.

[11]Formally, our model violates a number of assumptions in Balasko–Shell (1980). However, we can clearly construct an economy analogous to ours where preferences, aggregate endowments, and equilibrium prices and allocations coincide with those here. Moreover, such an economy can be constructed which satisfies all of the assumptions in Balasko–Shell, except for identical agents in each generation. However, as Balasko–Shell note, their arguments do not rely on the latter feature.

[12]Strictly speaking, the model implies not just constant, but zero nominal interest rates. Obviously we do not take this implication literally, since positive nominal rates would arise if there were any costs of intermediation or binding legal restrictions of any type under which banks operated.

[13]As previously, the assumption of logarithmic utility implies that the solution to this problem is identical to that which would obtain if the bank were also able to choose d_t.

[14]The same problem arises in Sargent–Wallace (1982), who use parameter restrictions to rule out the possibility of borrowers who simultaneously borrow and hold currency. For elaboration on this point see Sargent–Wallace (1985).

[15]See also Goodhart (1969, p. 30) and Sprague (1910, 1910a, b, c).

[16]We have examined the same series for Chicago and St. Louis Clearinghouse banks. These appear qualitatively similar.

[17]See also Kydland-Prescott (1990). The Hodrick-Prescott filter involves a smoothing parameter which we set equal to 14,400, based on a suggestion by Ed Prescott. We experimented with values of this parameter as low as 1600, with no important changes in Figures 3-8. We also experimented with other detrending procedures; regressing on time polynomials and log differencing, for example. The former resulted in no apparent changes in seasonal patterns, the latter preserved the seasonal patterns we report, but also induced some additional seasonal variation in the spring. This detrending procedure would not have altered any conclusions presented here.

[18]Of course other "Diamond–Dybvig like" models with currency exist; for instance, Smith (1987) or Loewy (1990).

[19]See Williamson (1990) for a further theoretical discussion of some of these issues.

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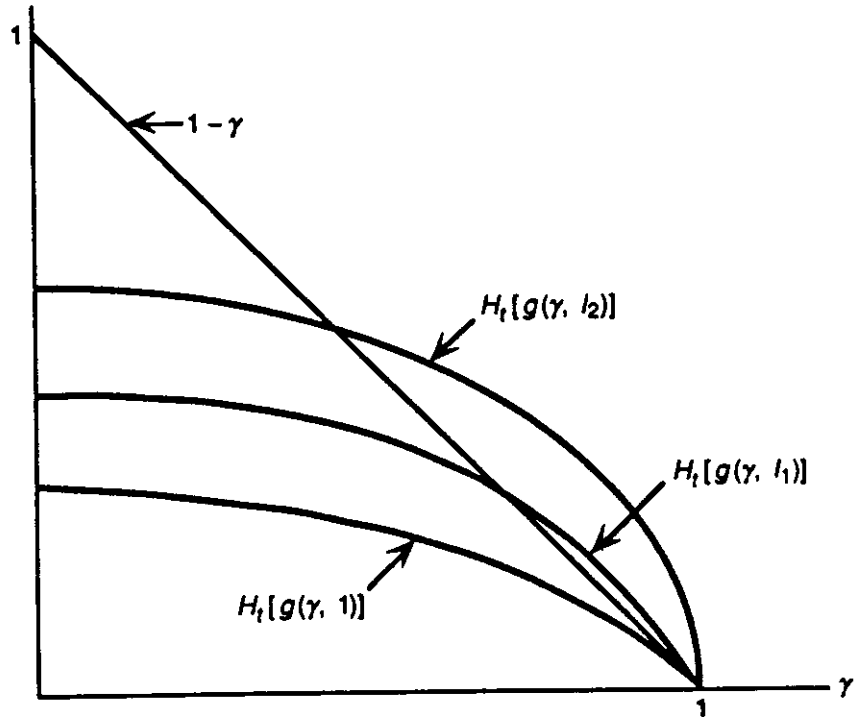

Figure 1

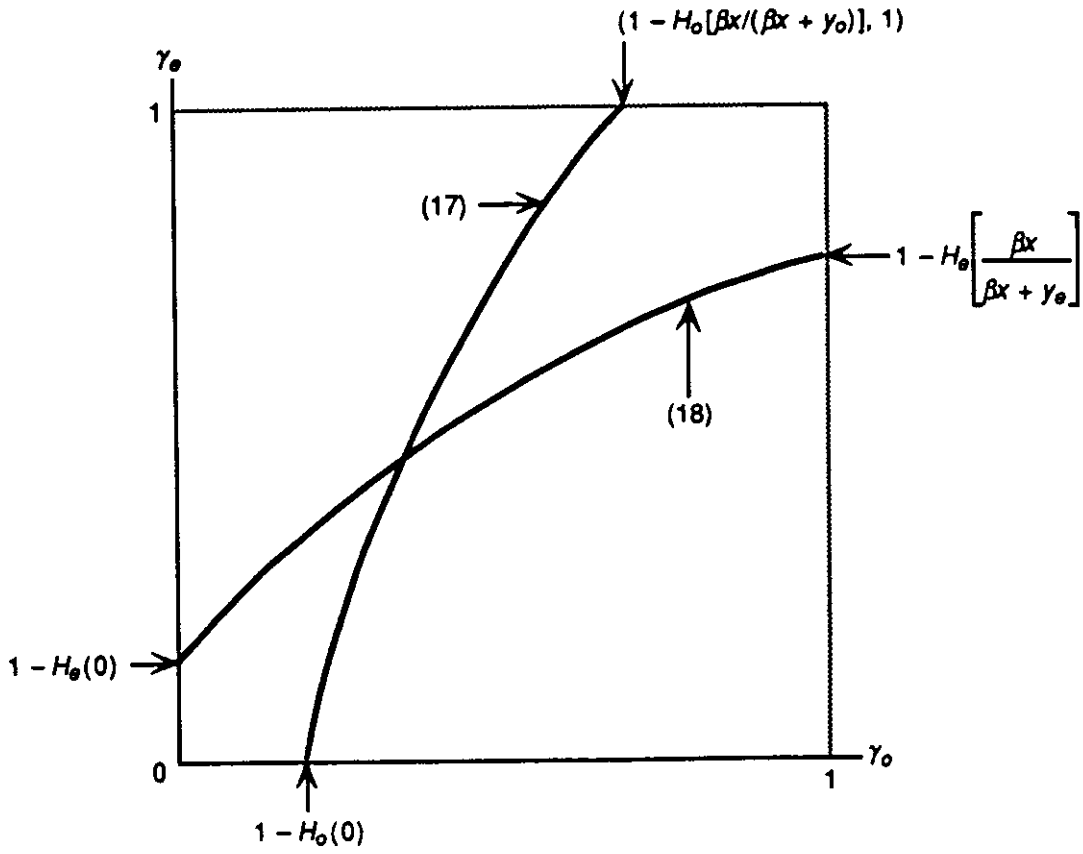

Figure 2

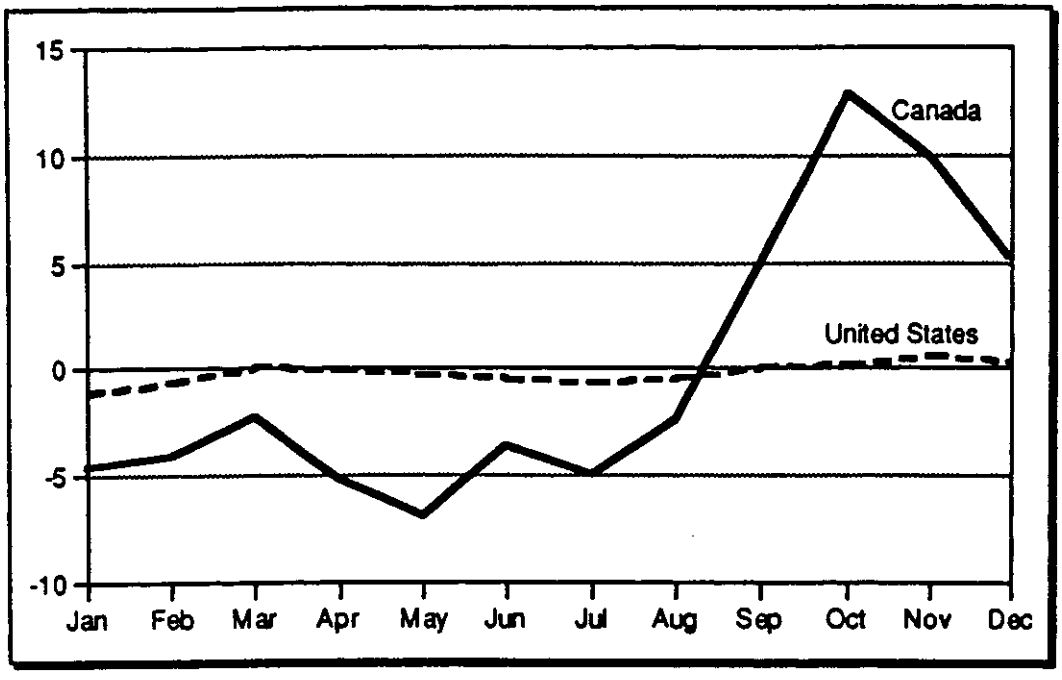

Figure 3. Banknote Circulation (Seasonal Coefficients, Percentage Deviation from Trend)

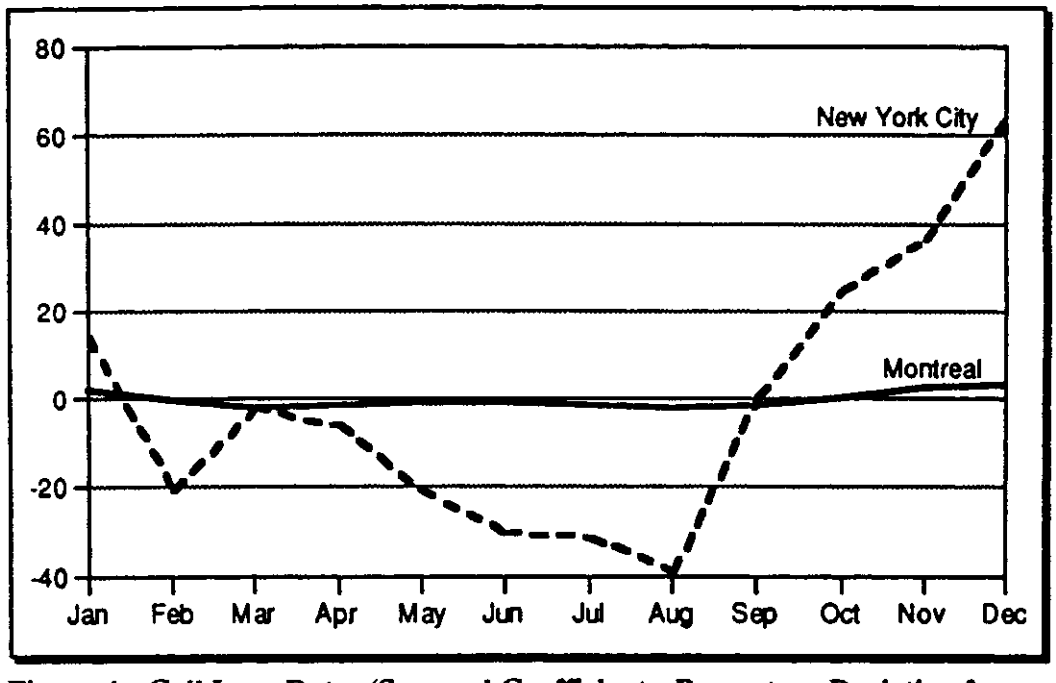

Figure 4. Call Loan Rates (Seasonal Coefficients, Percentage Deviation from Trend)

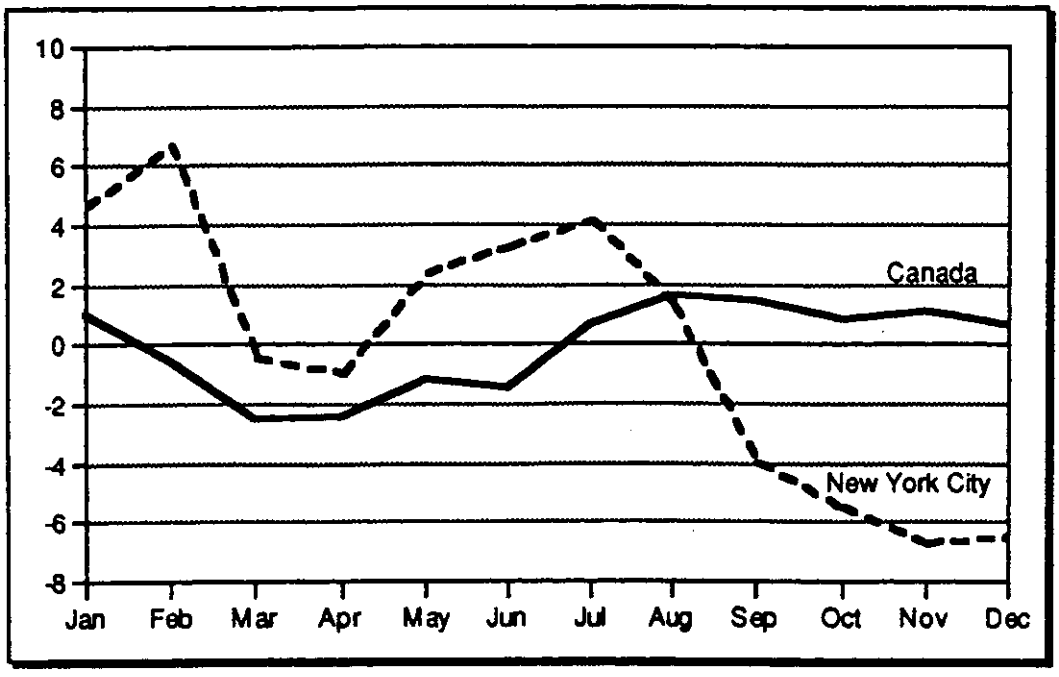

Figure 5. Cash Reserves (Seasonal Coefficients, Percentage Deviation from Trend)

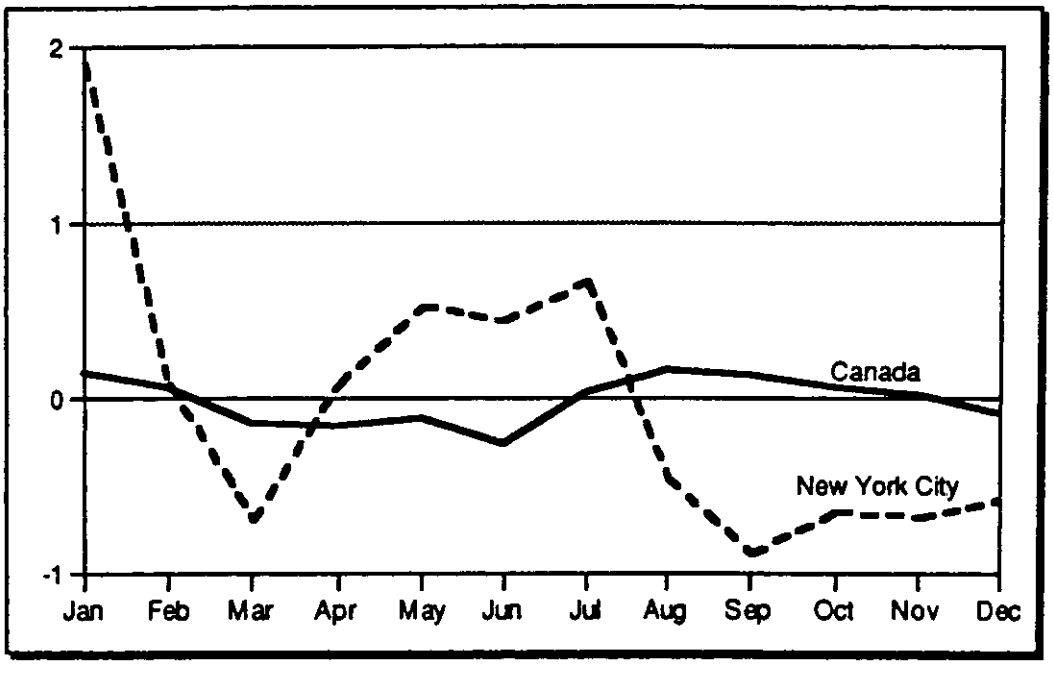

Figure 6. Reserve–Deposit Ratio (Seasonal Coefficients, Deviation from Trend)

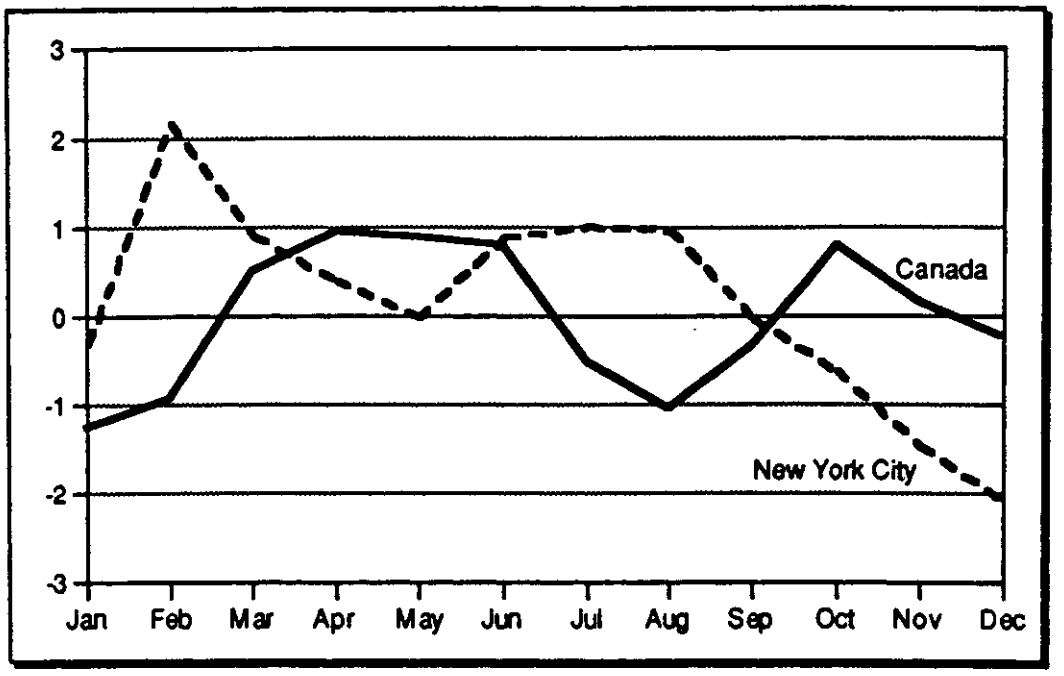

Figure 7. Loans (Seasonal Coefficients, Percentage Deviation from Trend)

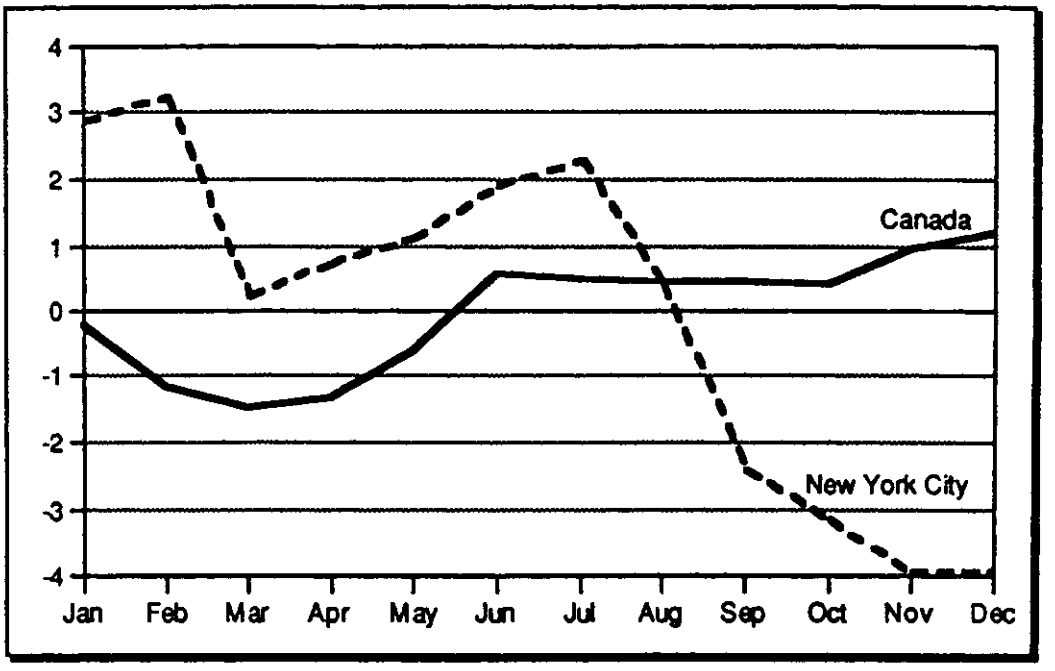

Figure 8. Deposits (Seasonal Coefficients, Percentage Deviation from Trend)

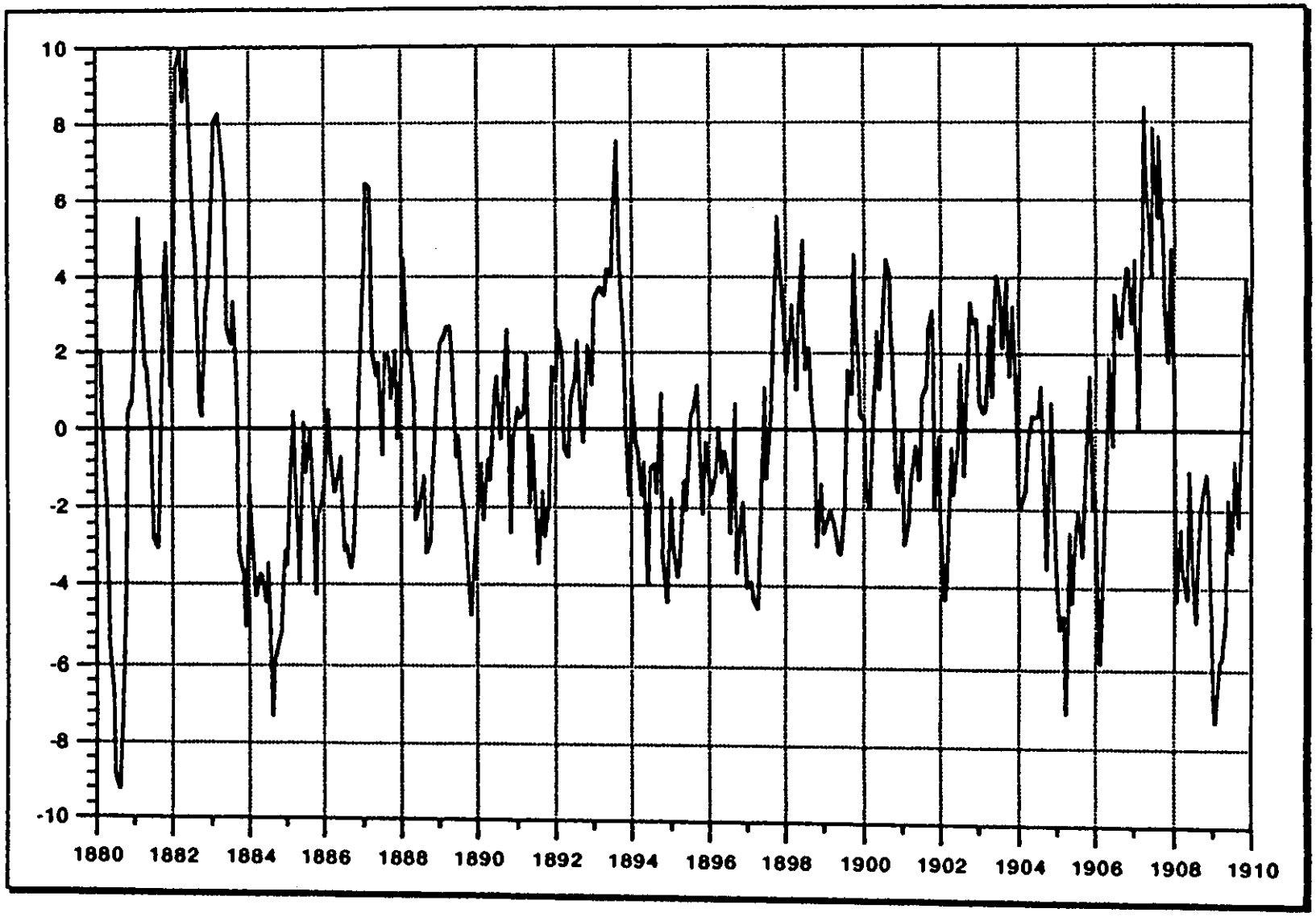

Figure 9. Canadian Banknotes in Circulation (Business Cycle Component)

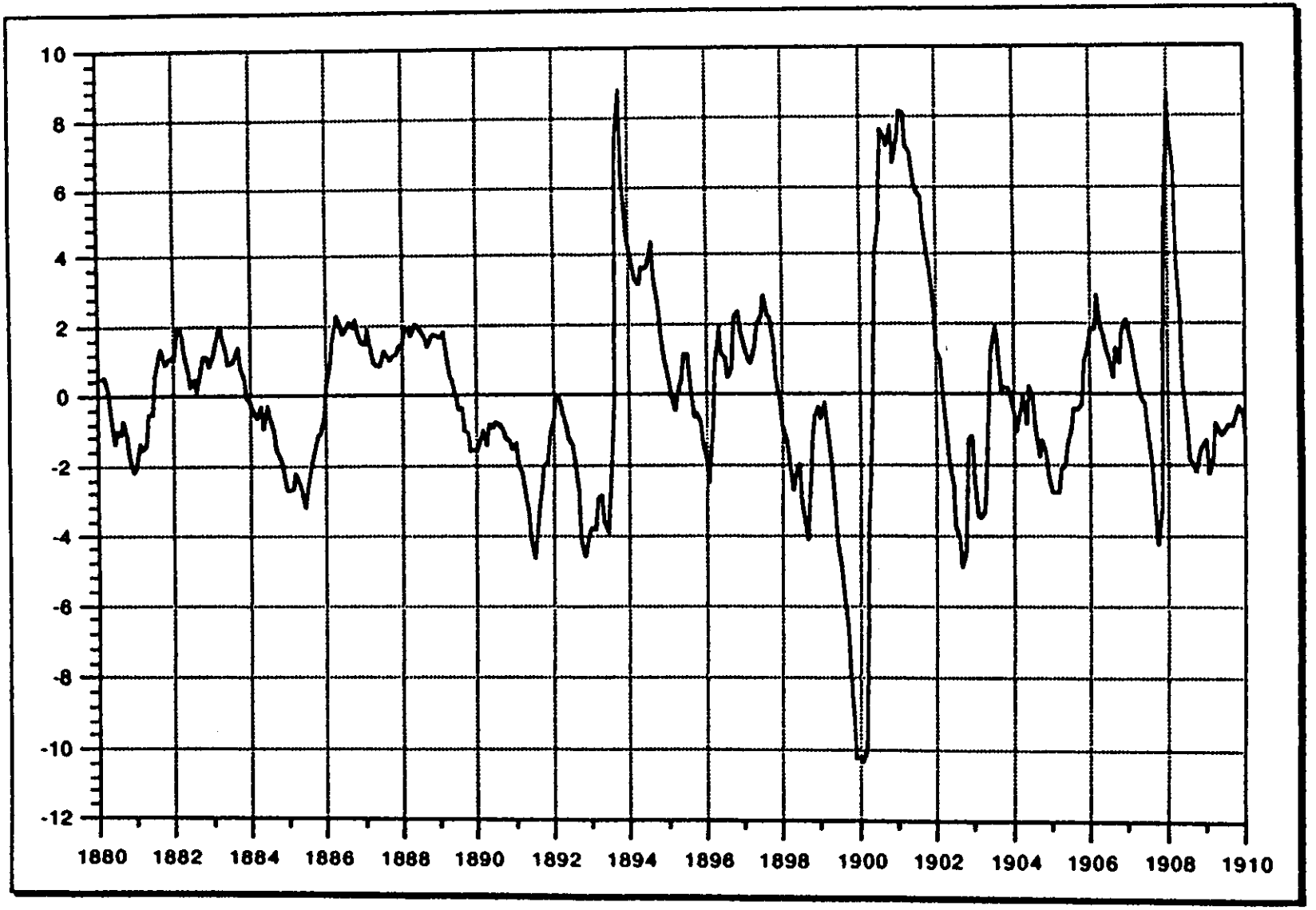

Figure 10. U.S. National Banknotes in Circulation (Business Cycle Component)

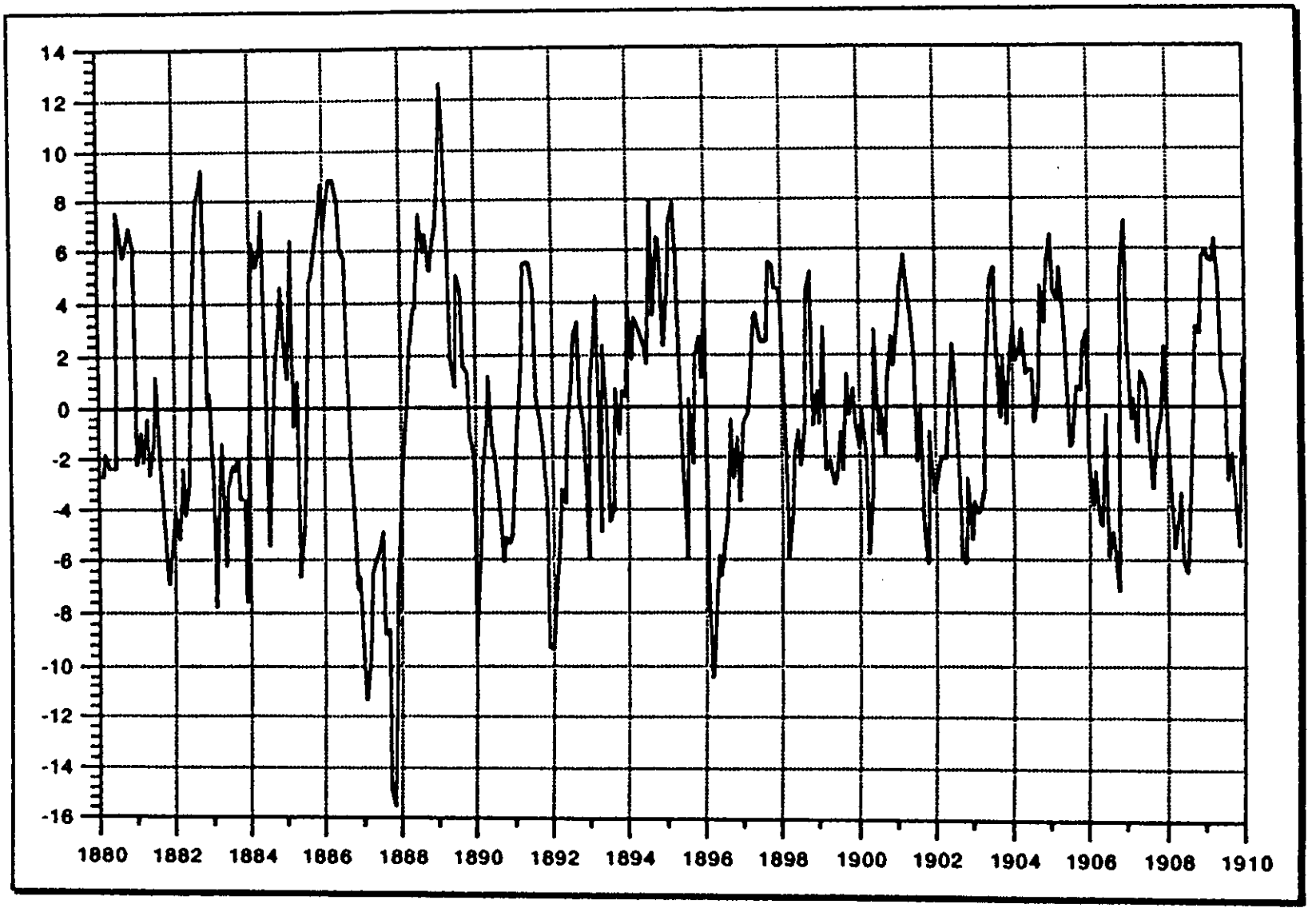

Figure 11. Canadian Cash Reserves (Business Cycle Component)

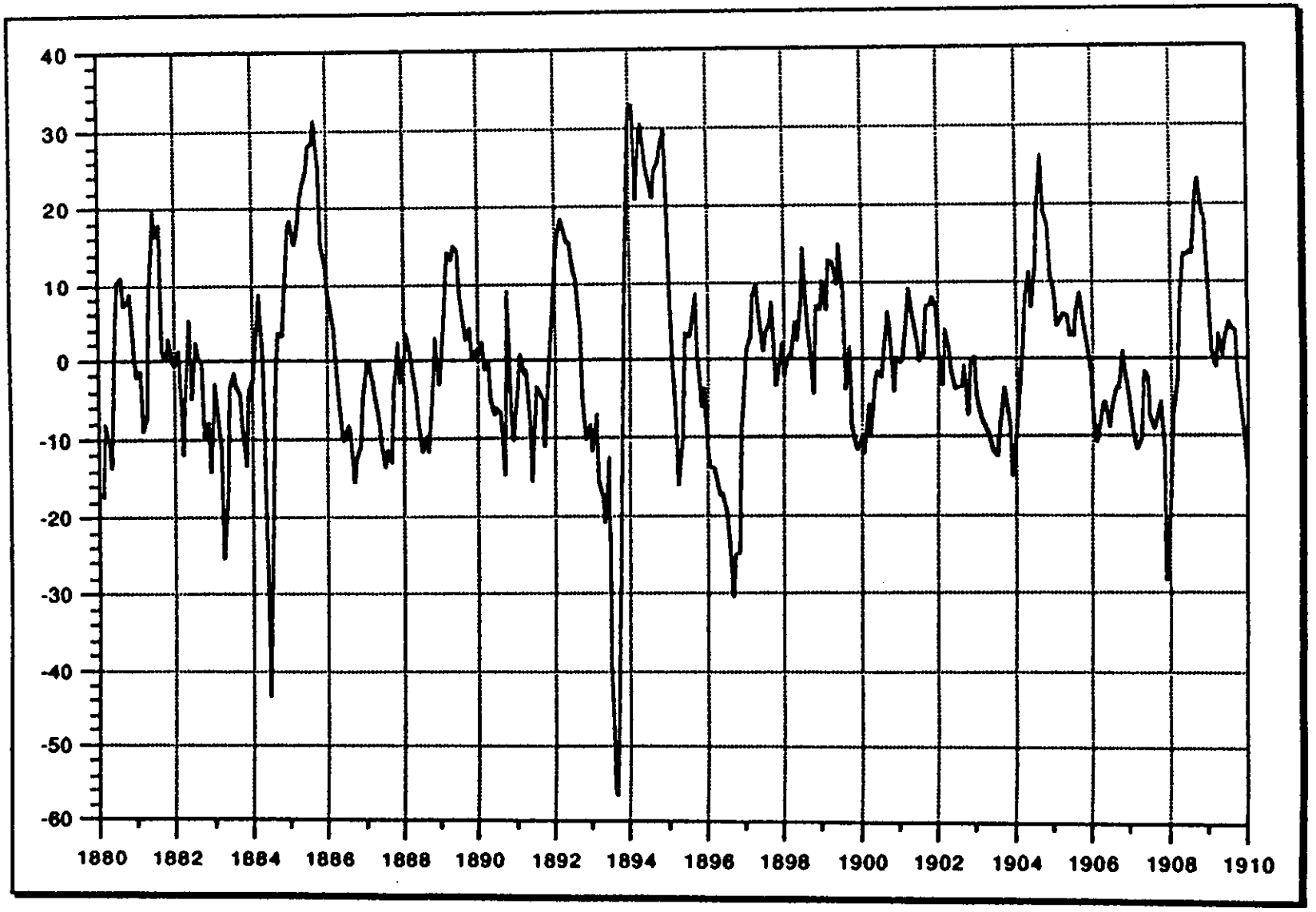

Figure 12. New York City Clearinghouse Bank Cash Reserves (Business Cycle Component)

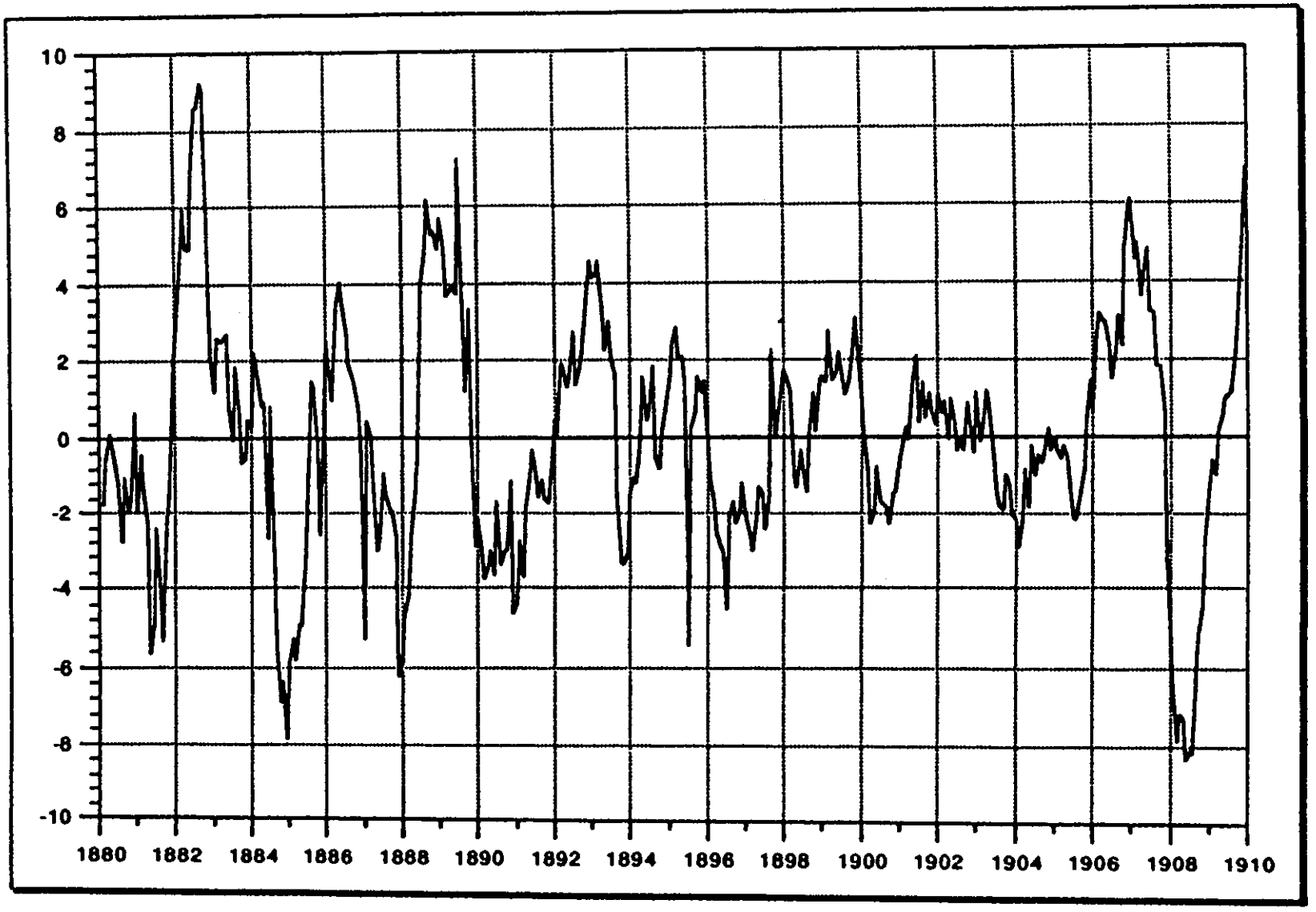

Figure 13. Canadian Total Deposits (Business Cycle Component)

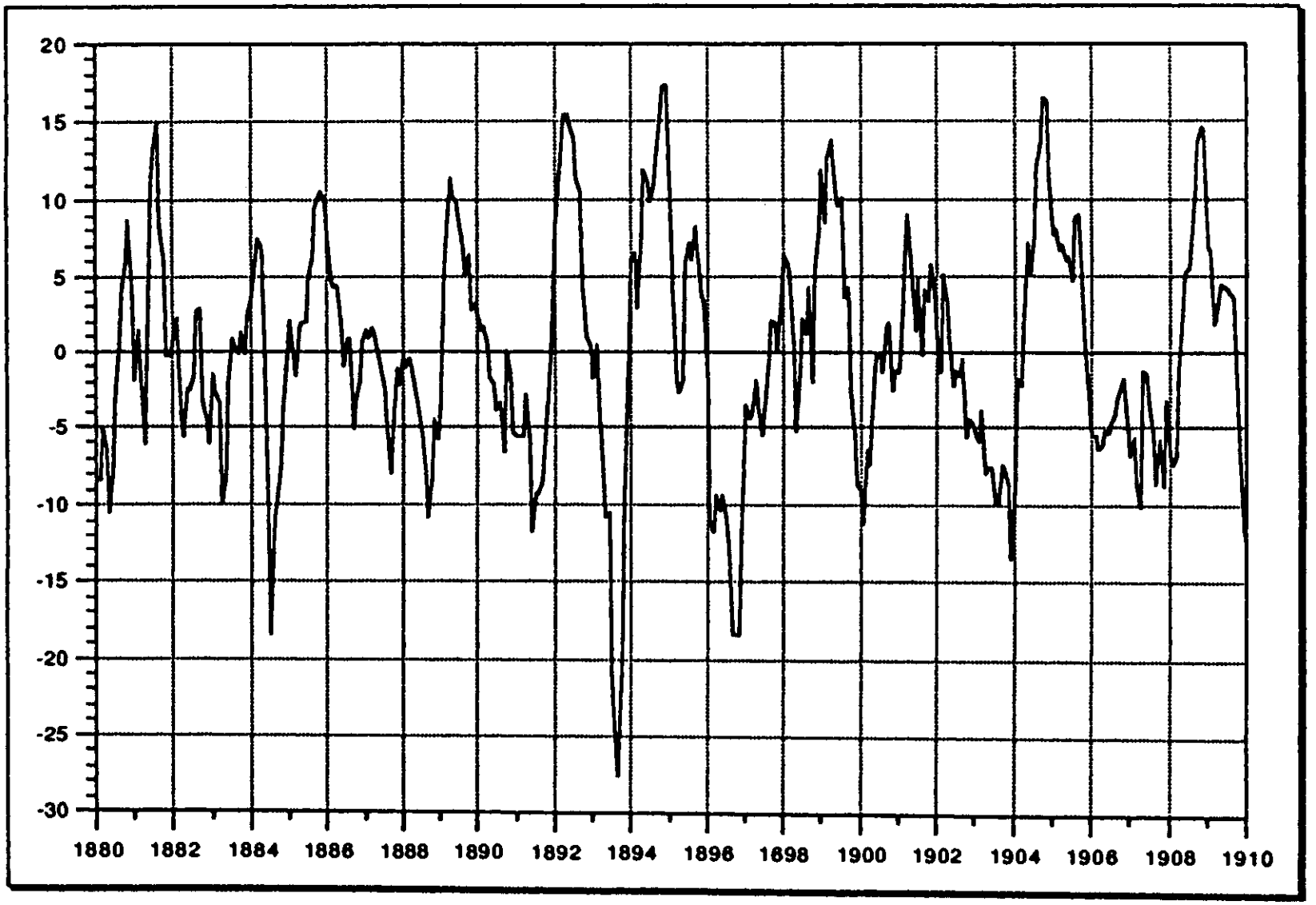

Figure 14. New York City Clearinghouse Banks Net Deposits (Business Cycle Component)

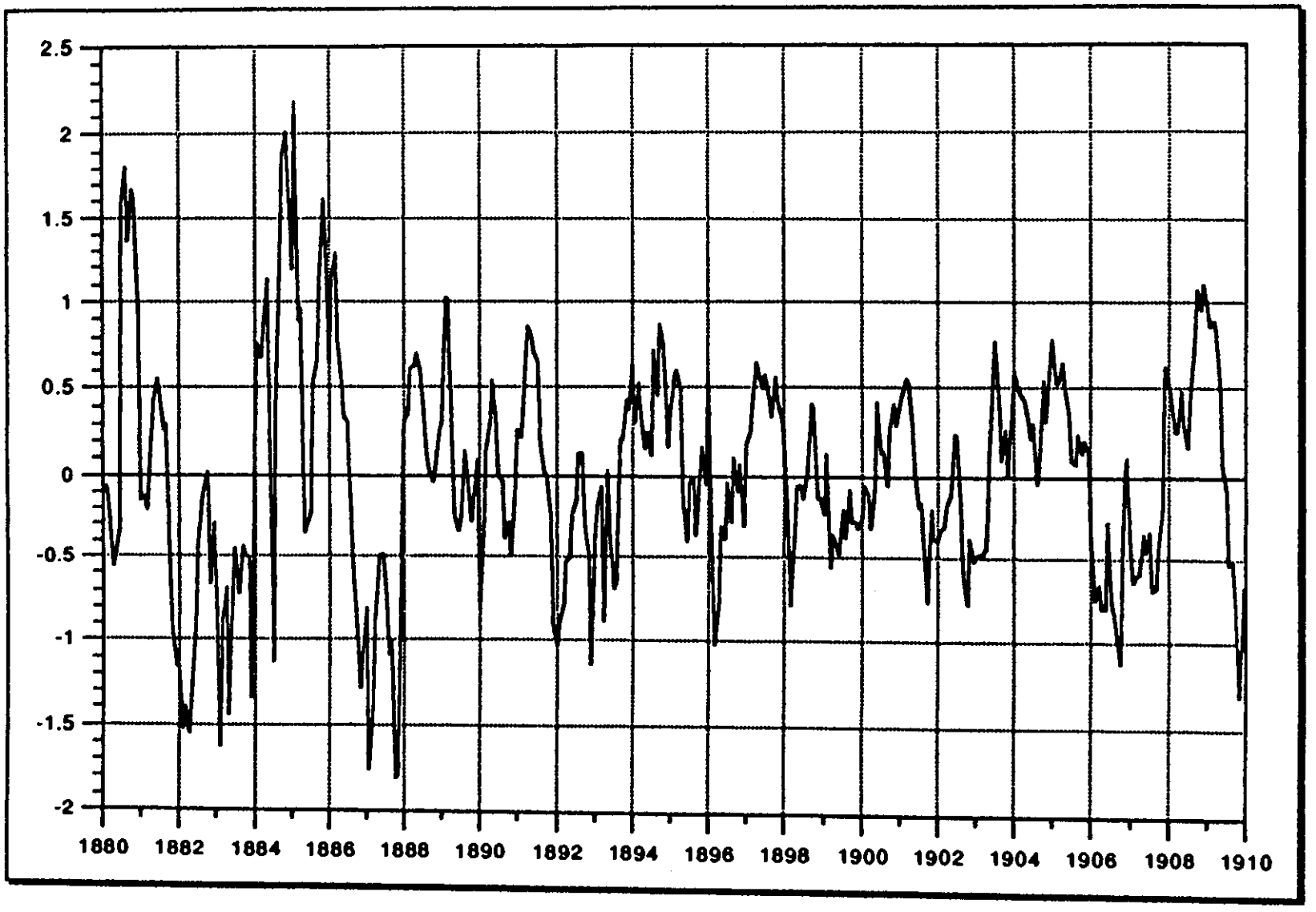

Figure 15. Canadian Reserve-Deposit Ratio (Business Cycle Component)

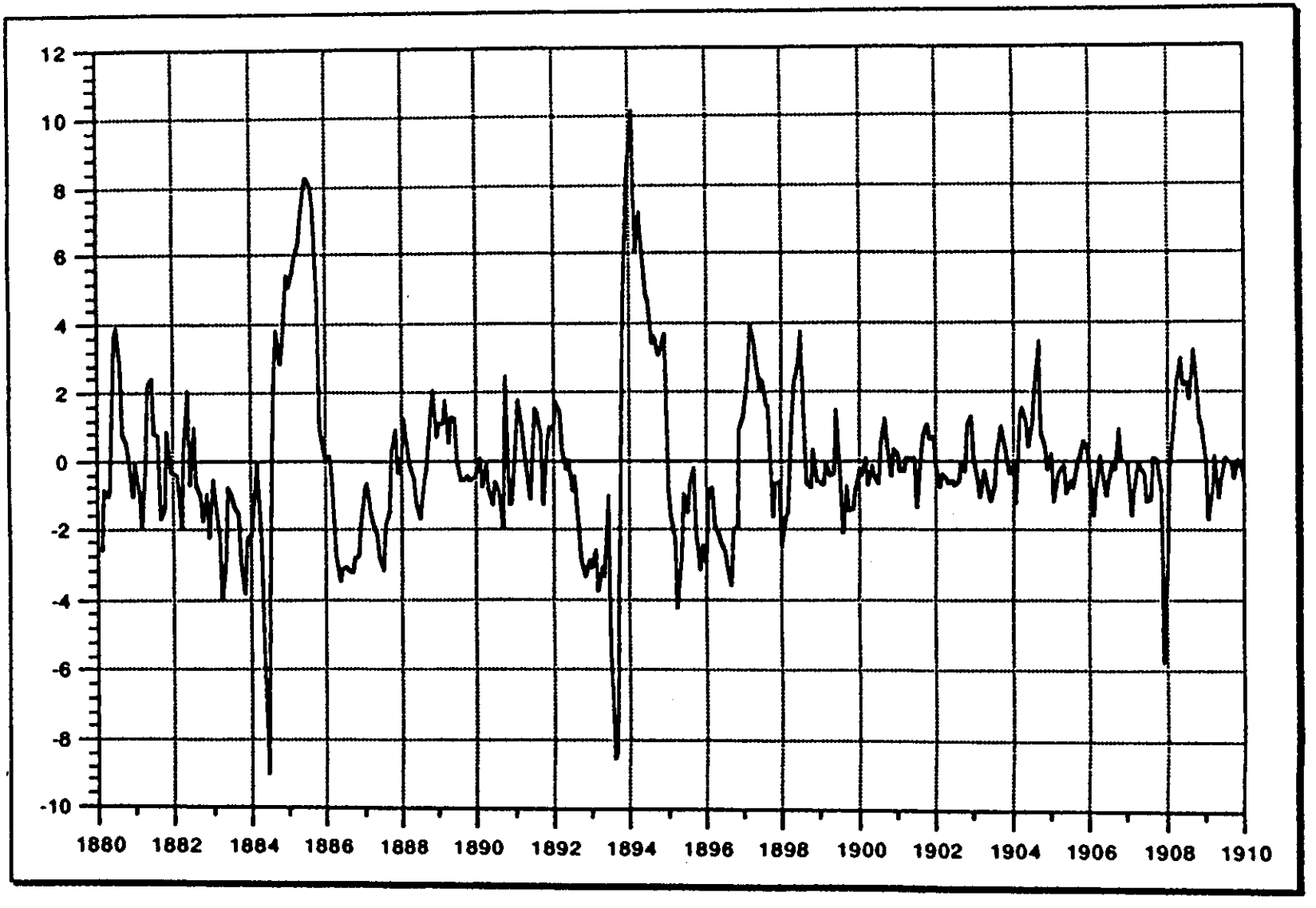

Figure 16. New York City Clearinghouse Banks Reserve-Deposit Ratio (Business Cycle Component)

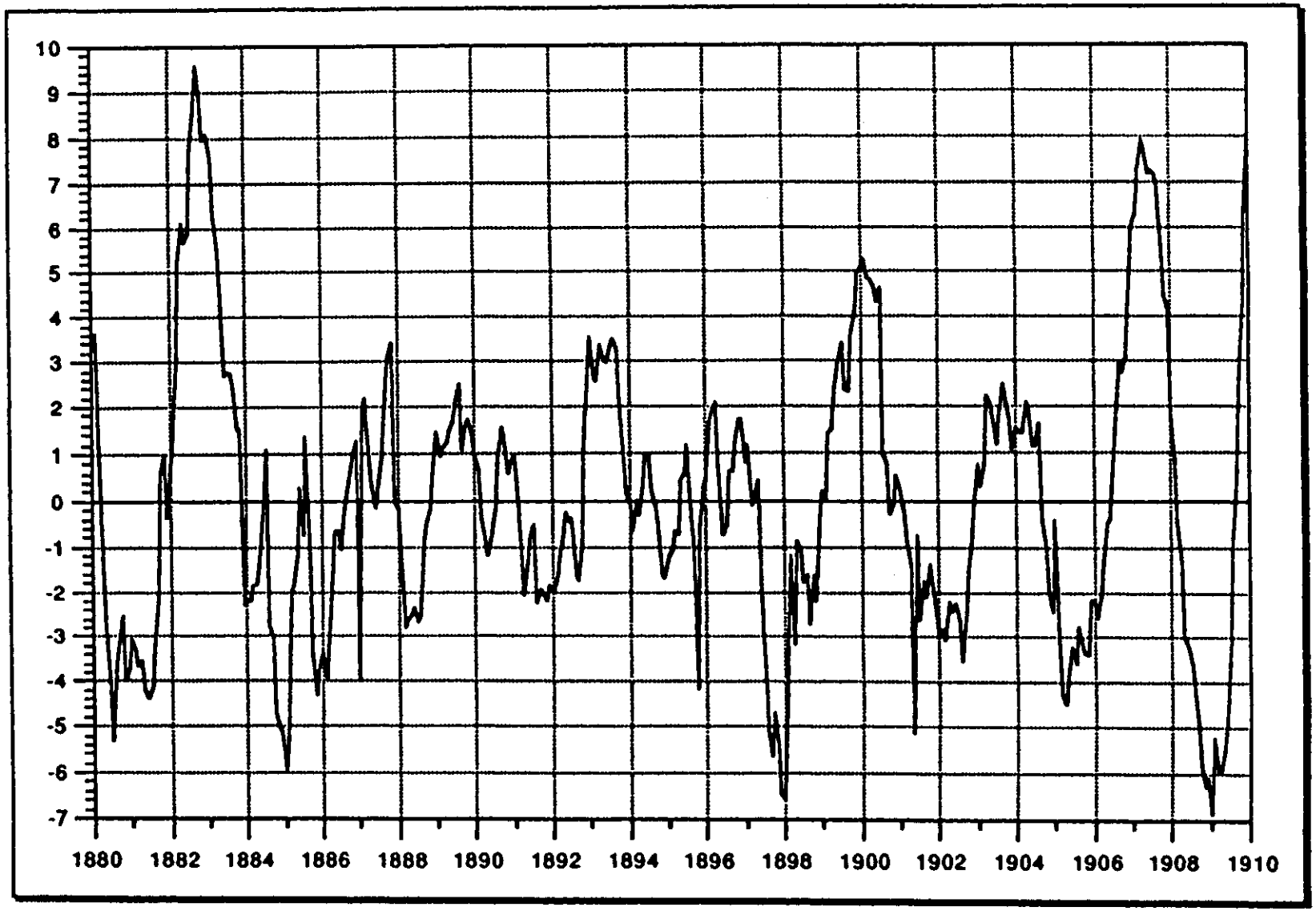

Figure 17. Canadian Total Loans (Business Cycle Component)

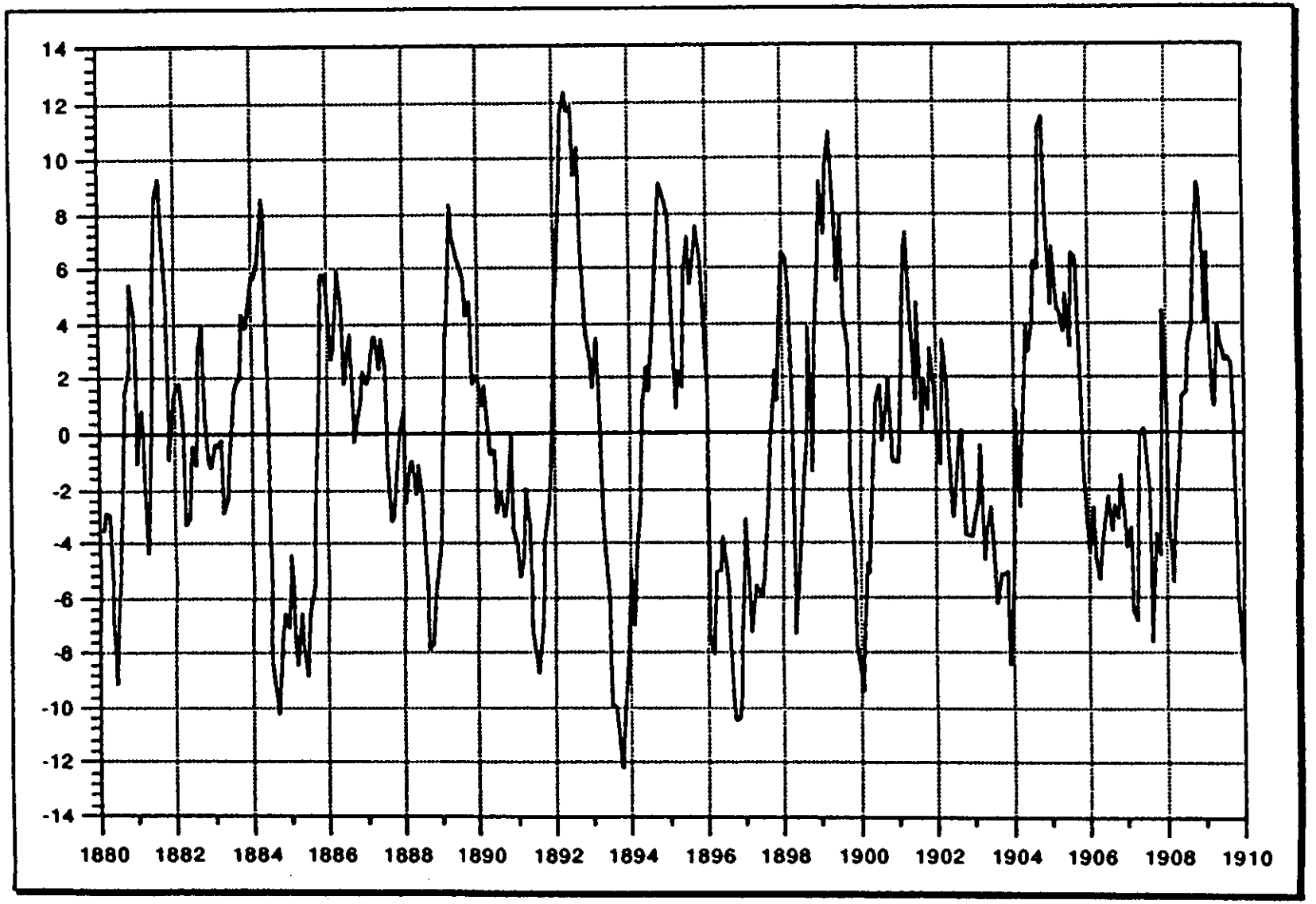

Figure 18. New York City Clearinghouse Banks Total Loans (Business Cycle Component)