The altered behavior of interest rates in the UK after the founding of the Fed in the US in 1914

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THE ALTERED BEHAVIOR OF INTEREST RATES IN THE UK AFTER THE
FOUNDING OF THE FED IN THE US IN 1914

A Thesis
Presented to the
Department of Economics and
the Faculty of the Graduate College
University of Nebraska
In Partial Fulfillment
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by

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THEESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College,
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ABSTRACT

The founding of the Federal Reserve System in the US in 1914 is viewed as a major structural transformation of the US economy. Scholars consider that the 1914 structural change of the US economy greatly altered the stochastic processes generating short term interest rates. In the US case, most short-term interest rate time series analyses suggest that prior to 1914 short-term interest rate time series were stationary whereas sometime after 1914 they became non-stationary. In addition to this finding, some researchers found that the same phenomenon occurred simultaneously in more European countries.

This thesis challenges the theory of simultaneous world-wide occurrence of the altered behavior of short-term interest rates after 1914. It employs 2296 weekly observations of the British 60-day bankers' drafts' rate between 1890 and 1933. Using augmented Dickey-Fuller (ADF) regression techniques, the empirical results suggest that the founding of the Fed had no connection with the altered statistical behavior of British short-term interest rates.
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The Altered Behavior of Interest Rates in the UK after
the Founding of the Federal Reserve System in the US in 1914

Introduction

The founding of the Federal Reserve System (Fed) in 1914 has had a crucial impact on the United States economy. Not only has the Fed improved the structural stability of the American economy, but it has also eliminated the large seasonality of interest rates that existed prior to the Fed's creation. Among scholars and researchers, the improved structural stability generated by the Fed is still a matter of debate (Capie and Rodrik-Bali, 1985; Goodfriend, 1987; Capie and Goodhart, 1995). Prior to the works of Clark (1986), Miron, Mankiw, and Weil (1987, 1994), and Fishe and Wohar (1990), the elimination of the interest rate seasonality, and the Fed’s responsibility for the changed behavior of short-term interest rates in the United States, after 1914, were issues widely agreed upon.

It is quite difficult to clearly distinguish the factors responsible for the changed behavior of the short-term interest rate time series. Initially, Mankiw, Miron, and Weil (1987) believed that, after 1914, the Fed had very much to do with the alteration of the interest rate behavior. Angelini (1994), and Fishe and Wohar (1990) argued that many other events could have influenced time series behavior of the interest rate. Perhaps the Aldrich-Veerland Act of 1908, or the Money Committee of 1914-1917, or maybe the breakdown of the gold standard in August 1914 could have been responsible.
In any case, in a later paper, Mankiw et al. (1994) admitted that the founding of the Fed might not be the only factor responsible for the altered behavior of interest rates after 1914. “The observed change in the behavior of short-term interest rates between the pre-1910 and post-1920 periods may have been significantly affected by other developments (e.g., the Aldrich-Veerland Act, and the Money Committee of 1914-1917), quite apart from the foundation of the Fed.” (p. 551)

To complicate the issue even further, Clark (1986) showed that the same phenomenon occurred at the same time in many other countries of Europe. In England, France, and Germany, the short-term interest rate behavior changed after 1914. From stationary time series it became non-stationary. This fact implies either that the American events could have transmitted the altered behavior of short-term interest rates to other countries, or that a common group of factors, or a single event, might have influenced all countries simultaneously. Previous works related to the pre-1914 short-term interest rate behavior (Friedman and Schwartz, 1963; Goodhart, 1969) argued that short-term interest rates “exhibited pronounced seasonal movements prior to the commencement of operations by the Fed in November 1914.” (Clark, 1986, p. 79) Clark (1986) showed that until the end of 1917 the Fed did not initiate the actions usually credited with the elimination of interest rate seasonals. Consequently, the Fed could not be responsible for the 1914 altered behavior of the short-term interest rates in the U.S. or abroad.

To test the 1914 break of the interest rate behavior, Barsky, Mankiw, Miron, and Weil (1988) developed a different theoretical model of interest rate, monetary policy, and inflation rates. They analyzed the interest rate pattern prior and after the 1971 breakdown
of the Bretton Woods regime and compared it with pre-1914 and post-1914 periods. Their main conclusion was that the “gold standard did not play a crucial role in precipitating the changes in interest rate behavior.” (p. 1123)

Clark (1986) argued that the Fed actions had nothing to do with the changed behavior of short-term interest rate after 1914. Barsky et al. (1988), on the other hand, argued that the gold standard did not influence the pattern of the interest rate after 1914. Is there a main cause that determined the changed behavior of interest rate in the US and UK after 1914? The next parts of this thesis will present an extended historical overview of the 1890-1933 British banking system. We will identify both the historical explanations for outliers in data, and the intricate relationships that existed in the British economy pre- and post-1914.

The main goal of this thesis is the study of the effects of the founding of the Federal Reserve in 1914 on the behavior of British short-term interest rate. The period under analysis is 1890-1933. We hypothesize the next issue: Did the Bank of England adopt similar objectives to those of the Fed? If this is true, then when did it begin to have objectives similar to those of the Fed? In other words, when did the Bank of England start to behave as if it were smoothing interest rates? This paper employs 2296 weekly observations of the 60-day bankers’ drafts rate. Although this rate was not directly determined by the Bank of England, it closely followed the official bank rate. The next three chapters of the thesis will include an extended historical overview of the 1890-1933 British banking system. Chapter 5 will present a brief historical overview of the Fed together with some theoretical considerations on the changed behavior of short-term
interest rate after 1914. Chapter 6 will describe the data and its outliers. After that, in order to evaluate the main properties of the British 60-day draft rate time series, augmented Dickey-Fuller (ADF) regression techniques will be used. The main conclusion and a reference list will end this paper.

Chapter 1. The Bank of England From Its Origins to the First World War

1.1 The Bank of England between 1694 and the 1800s

The Bank of England, founded in 1694, is considered the oldest central bank of the world even though the Bank of Sweden at Stockholm began “the first issue of actual bank notes in Europe in 1661.” (Clapham, 1958, p. 3) This is due in part to the specific privileges that the government gave to the Bank of England. In 1694 England was at war, and the government needed money to finance its increased spending. The Bank of England was a private bank chartered by the Crown to lend money to the government in exchange for promissory notes and other privileges. At its beginning, the Bank would lend money only to the government in exchange for the latter’s promise to pay back both the principal and the interest. In this way the Bank’s profits were strictly dependent on the government demand for loans. As long as the Bank would receive the amount of money it had lent to the Exchequer plus the promised interest, there would be a strong stimuli for the Bank to attract as much money as possible to its deposit accounts. Using this process, by 1696, only two years after its charter began, the Bank would issue standardized notes guaranteed by the government. In addition, the Bank performed the basic activities a
traditional bank of the time was supposed to do. These included discount operations, the use of write-off techniques to increase its deposit, the deposit itself, the issue of notes, and the use of checks for making payments.

It is worth mentioning that in 1696 the Bank of England issued two types of notes. One was its own, called running-cash notes (in large denominations), and the other one of the government, called the Exchequer Bills (in 10 and 5 pounds denominations). (Clapham, 1958, pp. 37-38) Basically, the Bank issued a note when a person deposited gold with it, and a different type of note when the government borrowed money from it. Eventually, the Exchequer Bills were made acceptable in the payment of taxes.

In 1697 the Bank privileges were reinforced by a new law. The law would give the Bank the ability to expand the standardization of its note issues, to increase the volume of discounts, and to begin its very important trade in precious metals. But perhaps the most important achievement of the Bank of England after the 1697 law would be the promotion of commerce and finance activities in London. As long as prior to 1697 the Bank had changed frequently the look and design of its note issues, standardization of the Bank note issues was important to both institutions and public.

Despite periods of uncertainty, caused by frequent wars across Europe, the activity of the Bank of England expanded considerably during the eighteenth century. The discount operations of the Bank began to be openly regulated by its directors. Mainly, the discount operations included any domestic drafts with a maturity no longer than 30 days, and any foreign bills with a maturity under 60 days. The rates of discount would be
changed regularly depending on many factors, such as the South Sea crisis or the Seven Years' War (1786-1783).

However, there were two official institutions that could trade precious metals: The Mint and the Bank. Basically, they had the same objectives but the Mint could not issue its own notes. Although the trade in precious metals was a statutory right of the Bank, there were no rules that would regulate the rivalry between the Mint and the Bank.

Nevertheless, the Bank would “buy gold and silver on the best terms it can for the service of its purposes.” (Ibid., p. 132) At the beginning of the eighteenth century the Bank would offer itself as the central warehouse for treasure, and occasionally, to store any imported gold or silver for which the bills of lading were deposited with it. Accordingly, the Bank developed the policy of making loans against gold or silver deposits.

Periodically, the charter of the Bank of England would be renewed. (The charters were to be renewed at 50 years spans, but in fact they were renewed earlier, in 1764, and 1781.) At the same time, the new charters would further clarify the objectives of the Bank.

The nineteenth century would begin under adverse conditions for the Bank of England. Between 1797 and 1821 the Bank suspended its cash payments to other commercial banks because of the economic crises generated by the American and Napoleonic wars (1793-1815). The British national debt went up, general goods and gold prices also went up, so that it became more and more difficult for the government to finance the war efforts of the Crown. Once the cash payment resumed by the Bank in 1821 the general price level started decreasing. It was not clear if the causality between the
resumption of cash payment and the price deflation was very strong, since it could as well happen that the velocity of money or the credit substitutes use increased.

Between 1821 and 1825, Britain passed through a period of economic recovery and prosperity. Eventually the recovery turned into a boom with full employment, strong inflationary pressures, and speculation in both the capital market and commodity markets. (Collins, 1988, p. 17) This led at the end of 1825 to a severe internal liquidity crisis, which depleted the reserves of the banking system. The Bank of England only in the end averted the threat to convertibility to its own notes, by freely lending money to those who requested it. For this reason, the government took actions to prevent such reoccurrence in the future. The new law would challenge the Bank of England’s privileged positions by allowing the formation of banks with an unrestricted number of partners outside a 65-mile radius from London, and by asserting the right of the new type of bank to participate in the discounting of bills in London or elsewhere, provided the bills were not drawn on the bank itself. However, the law itself could not do much to avoid the economic fluctuations whose consequences would, in the end, impose more responsibility for the Bank’s actions.

Since the main objective of this thesis is the study of change in the time series behavior of the interest rate after the creation of the Fed in 1914, and the data set used covers the 1890-1933 time frame, the next two sections of the paper will study in more details the economic and historical events between 1890 and 1933.
1.2 From Bimetallism to Monometallism

Starting with 1694, when the Bank of England began its activity, and until its nationalization in 1946, when the government forcibly bought the Bank’s stocks, the Bank remained a privately-owned joint-stock bank. Thus, the Bank’s stockholders would expect a reasonable return on their capital. In no sense was the Bank a public agency or a department of state, but nevertheless at the end of the nineteenth century it had developed into a central bank. This does not imply that the Bank would control and regulate the monetary and banking matters on behalf of the government, as it does today. In 1697 the parliament denied charters to any other banks and in 1709 it limited the number of partners in all other banks to a maximum of six. In 1833 the Bank’s privileges culminated in the declaration, by parliament, of its notes as English legal tender. From then on, the Bank became the largest note issuer in the country -with a monopolistic power in London- and this fact led to the consolidation of its unique position in the British banking system.

Gradually, around the 1900s, the Bank accepted broad, public responsibilities for the maintenance of “healthy finance” by acting according to specific economic situations, to avoid threats to the value of the pound sterling. The Bank discouraged any speculative practices and would act as a lender of last resort even though it was not required by its statutes. The government did not interfere with the Bank’s activities and the Bank would be solely responsible for the monetary situation of the country.

In Europe, by the turn of the 20th century, the governments of most countries would promote “central banks” with the pre-determined role of “defending” the national currencies. France, in 1800, Italy, in 1878, and Germany, in 1876, had created central
banks with very well specified roles. The Bank of England had existed before, but around the same period its actions began to resemble that of the continental central banks. The crystallization of the Bank of England's activities was an evolutionary process encouraged by a multitude of factors.

First, the Bank management of the day responded to legal constraints and obligations, and mostly to immediate economic pressures. Occasionally, the leaders of the bank might as well have been aware of their public responsibilities, but in the vast majority of the cases their actions were the consequences of a trial and error process. From a profit seeking institution, at its inception, to a central bank of the nineteenth century, the Bank of England covered a far from smooth itinerary. Secondly, the Bank lacked any viable competitors. The Crown never considered seriously the establishment of a public bank for the issue of notes or the conduct of other commercial banking business, and in fact it retained full responsibility for the coinage. Under such circumstances, the Bank came to be the largest and most influential British bank. The scale of its business would greatly influence any kind of transactions on the London money markets.

The importance of the Bank was also emphasized by its general relationship with the government. From its first loans to the government and to the moment when it was in charge of handling the government's accounts, the Bank had an independent source of income, besides its commercial banking activities. Because the Bank was so big, it needed to hold huge reserves of coin and bullion against its notes and deposit liabilities. Thus, the government decided, after 1833, to keep the nation's gold reserve in the Bank of England vaults. Commercial banks have also gained from this new status of the Bank, so long as
more and more of their cash holdings would consist of Bank notes and deposit balances at the Bank of England. In this way it was much easier to meet their inter-bank debts or convert notes quickly to coin. This attribute of the central bank notes would define the Bank of England as the bankers' bank.

Moreover, in times of panic or liquidity pressure the Bank found itself in the position of the ultimate supplier of cash, as other commercial banks drew on their accounts or borrowed from the Bank in order to meet their own customers' needs. The Bank acted to defend the public against unexpected losses and the result was an increased confidence in the banking system. However, the evolution of the Bank environment was from a very limited legal constraint based on the obligation to maintain the free convertibility of its notes into coin, to a more elaborate legal framework, often imposed by the Bank's practices themselves.

The 19th century was a century of profound changes in Britain. Commercial banking became the backbone of British economic development. It is surprising to see how a private bank got excluded from sharing the newly created market for loans and services and became specialized in exclusive functional areas. The explanation given to this paradox was mainly of a legislative order. (Collins, 1988, p. 170) The Bank was the largest note-issuer and depository of England's gold reserve and had the only obligation to maintain convertibility of sterling. Even so, from time to time, the financial system would be stricken by crises. In those situations, because of its gold reserves, the Bank stepped in and made advances to the rest of the banking system so as to avoid a general collapse.
From February 1821 until the outbreak of the First World War, Britain was on a stable exchange rate in terms of gold. The Bank of England was assigned by law to preserve this convertibility. Still there was no rule on how was the Bank supposed to act in cases when there was a threat to the gold standard. Several major crises characterized by “acute oscillations in monetary variables” (Ibid., p.172), called for strong regulation. In 1825/26, 1837, 1839, 1847, 1857, 1866 the cost and availability of bank credit, gold flows, and the number of bankruptcies underwent sharp changes.

The act of 1833 was the first step in allowing the Bank to diversify its monetary tools. The act abolished the legal maximum of 5% per annum on the rate of interest charged on promissory notes and bills of exchange drawn at or under three-month duration. Before this “liberalization” of interest rates, the Bank would have to ration the loans when the demand for loan would increase, whereas, starting in 1833 on, the Bank could practice punitive rates to slow down the demand for loans. The Bank’s intentional manipulation of the bank rate was to become an essential element of the 19th century Bank instrumental policy.

Although the gold standard -fully legally introduced in the United Kingdom in 1844- was in a minority among trading nations, it proved to be a well-inspired decision. Since the US had a bimetallic standard based on both gold and silver, and Belgium, Holland, Spain, Switzerland, France, Italy, and the main German states were tied to silver in one form or another, the United Kingdom had a privileged position. It gave a very solid base for financial intermediation. During the last quarter of the nineteenth century the actual price ratio of gold to silver decreased compared to the official price. The
speculative operations of financiers (based mostly in London) forced the vast majority of the central banks to officially change from (gold and silver) bimetallism to (gold) monometallism. After unification, Germany established a gold standard in 1873. In a short period all other European nations switched to gold. In 1879 the US, too, adopted gold convertibility.

1.3 The Golden Rule of the Gold Standard

As more and more countries joined the gold standard, exchange rates became more rigid. The international gold standard imposed a system of fixed exchange rates. It is argued that the main advantage of this system was greater price stability. Under normal situations, official obligations to exchange national currencies for a fixed quantity of gold, combined with the relative freedom to export goods and services, as well as bullion, specie and currency, would suffice to ensure stable exchange rates over a short term period between the participating countries.

In a completely free market, the rate of exchange between two currencies would be determined by demand and supply. The demand for a foreign currency relative to domestic currency increases if, say, in the domestic country the demand for goods imported from the foreign country increases. In this instance traders would want to convert more foreign monetary units into domestic units, thus increasing the relative value of the foreign units in terms of domestic units. At the same time, each currency had an official content in gold. Consequently, the implicit foreign exchange rate would be determined by the gold content ratio of the two currencies. Should the market forces
change this implicit ratio, traders had always the option of converting the undervalued monetary unit into gold at the official rate and eventually buying back the overvalued currency at the official convertibility rate. The effect of this operation would actually consist of decreasing the demand for foreign currency and thus reestablishing the equilibrium. This implied a self-regulatory mechanism that greatly depended on the official guarantees of the authorities to pay a fixed amount of gold for national currencies.

Between 1877-1933 the British pound was valued at 113.0016 grains of fine gold, and the American dollar at 23.22 grains of fine gold (99.996% purity). The implicit or official rate of exchange between the two currencies was 1 pound = $ 4.866. Holders of foreign currency would not accept anything less than the official rate as long as they could demand gold for their holdings and exchange it in domestic units at the official rate. The only deviation from the implicit exchange rate was due to the cost of remitting gold overseas. Yet, shipping, handling, and insurance costs would slightly alter the official rate. Collins (1988, p.132) estimated that, between 1877-1913, the actual exchange rate at which gold would be exported from Britain to the US was 1 pound = $ 4.857, while the gold would be imported in Britain from the US at 1 pound = $ 4.872.

1.3.1 External Balance Under the Gold Standard

Under the gold standard, the most important goal of the Bank of England was to preserve the official parity between sterling and gold. To do this the Bank needed (and had) an adequate stock of gold reserves. The government viewed external balance not in terms of current accounts but in terms of a situation in which the central bank was neither losing or gaining gold reserves. For instance, a deficit in the balance of payments had to be
financed by a shipment of gold abroad. In other words, the Bank of England tried to avoid large fluctuations in the balance of payments. Because international reserves took the form of gold, the surplus or deficit in the balance of payments had to be financed by gold shipments between central banks.

Starting with the American financial panic of 1907, some central banks (France, Germany, and Italy) began to hold foreign currency in their reserves. The pound sterling was the most trusted foreign currency. But most balance of payments was financed through gold shipments. To avoid large gold movements between countries, the Bank of England pushed the nonreserve component of the capital account surplus (or deficit) into line with the current account deficit (or surplus). In this way, the current account balance was financed entirely by international lending without gold (or foreign currency) movements.

1.3.2 The Price-Specie Flow Mechanism

The gold standard contained some powerful “automatic” adjustment mechanisms that contributed to the simultaneous achievement of balance of payments equilibrium by all countries. Assume that Britain’s current account surplus would be greater than its nonreserve capital account deficit. Since foreigners’ net imports from Britain were not financed entirely by British loans, the balance of payments had to be matched by flows of gold (or perhaps pound sterling) into Britain. The input of gold “automatically” reduced foreign currency supplies and increased pound money supply, reducing foreign prices, and increasing domestic (British) prices.
Imports could be paid for by gold reserves or by selling pounds to the Bank of England for gold and then using the gold to buy imports. The simultaneous rise in British prices and fall in foreign prices reduced foreign demand for British goods and services. The British current account surplus would be reduced at the same time with a reduction of foreign current account deficits. Eventually, gold flows stopped when external balance was reached. The same process worked in reverse to eliminate a current account deficit in Britain. (This mechanism worked only for extremely short periods, and it was never used in situation of financial crisis.)

1.4 The Bank Rate of the Bank of England: The Main Monetary Policy Instrument

Maintaining the gold standard became the primary objective of the Bank’s actions. Achieving both protection of gold reserves and economic growth were to become a major concern for the Committee of Treasury. The Committee of Treasury was composed of twelve members, most of them former governors of the Bank. The Governor of the Bank was required, according to the Bank statutes, to inform and consult the Committee of Treasury on major concerns of the monetary policy. The Committee of Treasury believed that an effective bank rate meant a leading rate and not a follower. We need to remember that the Bank of England competed with other commercial banks, and each bank could determine autonomously its own rate. The Committee of Treasury wanted that the bank rate to determine (somehow) all other market rates. Consequently, the bank rate was supposed to lead the market rates, and not vice-versa.
The Bank realized that in order to have an influence on the money market it needed to take measures to encourage further the money market business with the Bank. Such steps were taken in the 1890s and they were accompanied by an increased presence of the Bank's intervention in market conditions. The accepted doctrine was the fixing of the bank rate that would be announced weekly.

Sayers (1976, Vol. I, 28-9) asserts that "there is not the slightest indication in the Court or Committee of Treasury records of the reasoning on which each week's action was based." However, there is plenty of evidence that the Bank's main objective consisted in "preventing gold from leaving the country, or of attracting gold to the country." (Ibid., p. 29) The bank rate would be lowered when it was completely out of touch with market rates and circumstances did not render it necessary to induce the import of gold. We can see that the Bank's objectives did not have anything to do with the balance of trade or payments, the price level, the supply of money, employment, or speculation tendencies. Securing gold reserves was the main concern of the day. It has been noted (Ibid., p 32) that the Bank would raise the rate faster than it would reduce it.

If gold reserve were adequate and the market rate was high, the Bank would respond in a less effective way to move the market rate down. In other words, there existed an asymmetry in the Bank's manipulation of its rate. The rate was supposed to be much more effective when the gold reserve would be depleting. For instance, when gold was exported the Bank would increase its rate immediately. Of course, the gold would start to return to Britain. In this instance, the Bank did not reduce its rate to the former level as fast as it had increased it.
Another issue of concern in the gold standard equation was the high seasonality of the demand for money. For the Bank's leaders it was very difficult to discern between permanent and seasonal factors. In October, for instance, there would be an outflow of gold from Britain to the US due to the increased demand for gold of the US during the harvest time (US had a very inelastic money supply), situation in which regularly the bank rate needed to be increased. If the Bank leaders believed that in December gold might be coming back into England, then they should not have intervened in the money market. Had the Bank not changed its rate, at the end of the year the absolute level of reserve would have stayed intact and interest rates would have been less volatile. Consequently, because of seasonality, the Bank gained a greater margin of discretionary action. (It could increase the bank rate or it could not, depending on its own views on the economic situation.)

The London bill market determined the amounts of gold export and import. In other words, if a trader would have found it cheap to discount a commercial bill at a London bank he could have performed more transactions in England, and more gold would have come into England. Thus, if the Bank could influence the London bill market (the discount rate) using its bank rate it gained more predictable control over gold movements. In fact, in 1890s the Bank began expanding both its lending operations (mainly by discount and advance) and its advances operations only. The Bank extended the eligibility of bills it would take from ordinary customers and thus the limit of eligibility increased from 3 to 6 months to maturity.
Another issue connected to making the bank rate more effective was the method that the Bank of England would use to operate more directly on influencing market rates. The Bank did not carry a portfolio of bills it could sell to take money off the market. An alternative to selling bills was for the Bank to reduce the funds available in the market for the financing of bill' purchases by the discount banks. The Bank had either to sell a security of some kind or borrow funds that would otherwise be lent to the market. Borrowing was the preferred method used between 1891 and 1914. (Sayers, Vol. 1, p. 38) It was surprising that the biggest customer of the Bank, the Exchequer, did not provide any help in this matter. Only after 1914 did the Exchequer accept that the Bank could use its notes to influence the market rate.

The movements of the bank rate were directed at protecting the gold reserves. The rapid changes in the bank rate would hurt trade and industrial activity. A high bank rate would increase the discount rate and merchants would find it more expensive to finance their activity. We need to keep in mind that discounting was the main source of external financing for the vast majority of economic agents. Under these circumstances, at the end of the 19th century, the Bank became aware of the broader effects of its policies. In the 1900s it avoided the more extreme increases of the bank rates as much as possible, and it resorted to other measures with the objective to evade or moderate actual rises in bank rate. After the crisis of 1905-1907, the Bank required its branches to “avoid as much as possible any curtailment of our regular customers for trade purposes.” (Ibid., p. 45) Also it advised commercial banks to cut down commitments to finance speculation in New York. (p. 44)
Although the classical gold standard prohibited it, the Bank pursued a policy of altering the gold price in order to encourage or discourage gold export or import. Normally, the Bank calculated appropriate buying and selling prices for the principal foreign gold coins, which would leave shippers indifferent between handling gold or other forms of gold coins, while leaving the Bank a margin of profit when a quantity of coins was resold in the same form. Theoretically, this should have been a stable mechanism for the free import and export of gold.

But, on occasions, the Bank altered unilaterally (without a counter-actions from the part of the corresponding foreign central bank) the price of gold of some foreign coins in order to defend its gold reserve. If the Bank did not want some specific gold coins to leave the Bank’s vaults, it would simply increase the selling price of those coins. Because of this increased price, commercial banks or other money market operators were discouraged from buying those specific gold coins (from the Bank reserves). On the contrary, if it wanted to attract some gold coins into its vaults, it would just increase the buying price of those coins. Sayers argues that “governors sometimes decided that one or another of theses devices was useful in the over-riding task of ensuring adequacy of the gold reserve.” (p. 51) Often this policy of direct intervention on the gold market was accompanied by a change in the bank rate. The efficiency of such combined policies increased, but the frequent and, sometimes, major fluctuations of the bank rate were a major concern for the Bank’s leaders.

The 1906-7 American crisis proved that the bank rate combined with borrowing were effective methods of controlling the monetary market. In the spring of 1906 the
economic difficulties in the US (caused by an increase of the interest rates) had depleted the Bank of England’s gold reserve. The first reaction of the Bank was to increase the bank rate. In August when speculation in New York increased, the Bank used borrowing in the discount market to increase the market rate. This step was not enough to stop gold exports and it was combined with an increase in the bank rate. Latter on, these measures still were not sufficient and the Bank started discriminating against the paper on which money had been raised for lending to speculators in New York.

The selling price of the American eagles was raised to its maximum, but market rates were continually above their official rate. Yet, a new set of similar operations were undertaken and the results became observable. The gold imports increased and the bank rate eventually decreased. In October of 1907 the crisis gained momentum once again. The Bank did not hesitate and took one more step to prevent a new gold export wave. Since there was a correlation between the gold reserve and the interest rate, the Bank intended to avoid any increase in the interest rate that could have affected the British economic activity. In addition, it refused to take any long-dated bill, so that although market borrowing further increased, market rates remained above official rate. In November 1907 the Bank had to increase its rate to unprecedented levels not seen since 1873 (a rate of 7 per cent). Because of this high rate, by December 1907 gold was coming into Britain from twenty-four countries. (Sayers, p. 59) At the end of January 1908 the bank rate had fallen to 4 per cent.

In this chapter we have described the most important evolution the Bank of England passes through between 1694 and WWI. In more than two centuries, the Bank
transformed from a purely private bank to a bank with goals similar to those of a contemporary central bank. Next chapter will present details about the evolution of the Bank of England during the difficult war years and until the Great Depression.

Chapter 2. The First World War and Its Impact on the Bank’s Activity

2.1 From a Public to a Central Bank: The Crisis of 1914

The First World War marked, for the Bank of England, a significant step toward its transformation from a public to a central bank. Continental European countries anticipated the war for several months. The sterling or bills drawn in sterling were the most accepted mean of payment, and the world’s pressure on British denominated assets had visible repercussions on the British economy.

In the first part of 1914 fear of war caused heavy sales of internationally traded securities. Foreign borrowers were not able to remit in time (to the London accepting houses) funds for paying bills falling due in the next couple of weeks. Clearing banks found themselves in a liquidity crisis. The historical solution to any liquidity crisis of the banking system consisted in the Bank of England intervention. Commercial and discount banks would seek immediate cash in exchange for bills. Although the Bank of England did help the market in this way, the help would not be enough.

Following a decision taken by the Stock Trade Committee, on July 31, 1914 the London Stock Exchange was closed. The discount market’s borrowing at the Bank of England soared. Concomitantly, the gold position aggravated more the fragile situation in
the money market. Foreign exchange rates were not favorable to the Bank of England, and gold was being exported in massive amounts. Clearing houses ceased or rationed the payments of gold to their customers in exchange for notes. This action exacerbated even more the pressure on the Bank of England’s gold reserve. The bank rate was more than doubled from 4 to 10 %. Because most countries lost their confidence in sterling and despite the attractive level of interest rate, there were no overseas funding pulling in as it used to be. The Bank remained closed for a week (between August 3rd and August 7th) and when it reopened the bank rate fell back to 5 %. The rate would remain at this level for the next two years of war. When it reopened the First World War had already begun.

During the week when the Bank was closed, the Bank had to issue new notes. Technically, the Bank issued the new notes as loans to commercial banks in proportion to their deposit liabilities. Commercial banks paid an interest rate given by the bank rate, which was considered by the Bank of England as the minimum rate for lending. Since Scotland did not recognize the authority of the Bank of England, the Bank issued Treasury notes so that these could be accepted in Scotland. As a consequence, in a very short period, the Treasury notes issued by the Bank would become the main part of the circulating notes in both England and Scotland. After August 20th commercial banks took these notes instead of gold when drawing cash used to meet customers’ necessities.

These measures proved to be extremely effective in controlling the immediate crisis. Bill holdings were again liquid and the public confidence was restored. The Bank of England gained not only the public’s acclaim but the commercial bank’s support as well.
However, the international effects of the war were devastating and London's premier position on the international financial markets would never be restored (after the war).

2.2 Impact of the First World War on the Bank's Activity

The crisis of 1914 made clear that the Bank of England was the main protector of financial stability. Government intervention in the economy increased without any precedent. During the war years the government strictly regulated the capital markets, the imports, the distribution of food and vital materials, many retail prices, and the employment force. (Collins, 1988, p. 272-3) Also, the government directly controlled or managed the coal mines, the railways, and large portions of the armaments industry. All these were accompanied by increased taxes and public borrowing. Consequently, the ties between the Treasury and the Bank of England fortified. In addition, the collaboration between authorities and money market institutions intensified.

The Bank of England pivotal role in the money and credit markets extended. It became the first lender to the government before markets had settled down. In November 1914 the government initiated the long-term borrowing with a ten-year maturity. In addition, the government could borrow at much lower rates than the bank rate. In 1915 the government issued a public offer of war bonds, but the Bank of England had to step in because the offer was undersubscribed.

A different aspect of the precarious London financial situation during the war centered on the question of gold payments. Should gold payments be suspended? This question was a very sensitive one. John Maynard Keynes favored a limited maintenance of
specie payments “so as to meet foreign demands, while making it extremely difficult and inconvenient for the ordinary man to get gold.” (Sayers, Vol. 1, 1976, p. 84)

The declared objectives of the Bank included its assurance that the banking system as a whole would facilitate the war effort; to conserve the principle of external convertibility of the pound sterling; to lure to London as much foreign currency as possible; and to acquire the channels necessary to attract war supplies from other countries (mostly from over the Ocean). Before the US entered the war in March 1917 there had been discussions between France and Britain, on the one hand, and the US and UK on the other hand, to buy as much war supplies as possible from the US. The financing would not be assured in all the cases by the European central banks. In those instances when there was no agreement between the purchaser and the buyer, some American intermediation firm (Morgans) would perform foreign exchange transactions, mobilization of U.S. securities held abroad, flotation of public debt, and overdrafts on behalf of foreign governments.

Little by little, the British balance of payments would swing one way only (always in deficit), and since there were fixed exchange rates, gold started crossing over the Ocean, first to Ottawa, and then to New York. Because the speculation was that more gold would be shipped over to the US, the value of the sterling would depreciate even more compared with the US dollar. At this point, in November 1915 the Treasury appointed a committee whose main role was to defend the exchange rate. Although the committee proved to be very effective with respect to other exchange rates, it was not effective with the US dollar exchange rate.
The next step for the British Treasury was to borrow money directly on the New York market. In the Fall of 1916 Britain issued Treasury bills in New York. Yet, the Fed did not allow the American banks to buy these bills until February of 1917. (The US would enter the war next month.) After April 1917 the cooperation between the Bank of England and the Fed would intensify. As a consequence, more inter-government loan agreements would be signed in April and May of 1917.

During the remaining period of the war, the issue of government stock reached unprecedented levels. Since both the Treasury and the Bank wanted to attract more “deposits” into their accounts, the Bank had to use an additional type of interest rate: Treasury Bill rate. For this reason the Bank started differentiating between deposit rates on home and foreign money. The rate on foreign deposits remained at a higher level than on domestic rates. (For instance, in January 1918 the rate on domestic deposit offered by clearing banks was 3.5 % whereas for foreign deposit was 4.5 %.) Commercial banks were also required to discriminate on the same basis. At the end of 1917, due to a higher influx of foreign deposits and severe restrictions on the exports of capital the Treasury bill rate fell from 4.75 to 4 %. Treasury hoped that these reductions of rates on the short term deposit would encourage people to invest in longer term bonds that were still issued.

For the Bank of England, the broader association with the government and with the conduct of monetary policy increased its influence within the domestic economy. Some of the responsibilities for managing the national debt could limit the Bank’s actions so long as the government had somehow more divergent interests than those of the Bank. Only when the war was over could the Bank clarify its divergence with the Treasury. Generally
speaking, by the end of the war, the Bank of England had already become a pillar of the British economy, although its roles were not accurately defined and understood.

Chapter 3. The Return to Gold in 1925 and the Economic Crisis of 30s

3.1. The Accumulated National Debt and the International Cooperation after War

During the war, the Bank of England lost control almost entirely over the quantity of money in circulation. Since the Treasury had issued bills to cover the financing needs of the war economy, the market could get unlimited cash at the discount rate at which Treasury bills were available. In other words, there were two issuers of notes. In addition, both types of notes played similar roles. By the end of the war the government accumulated a huge deficit. Usually, the government issued new notes to pay off its “older” debt (consolidate its debt). Consequently, since the government wanted a lower rate to re-finance its debt, it preferred lower interest rates. (We need also to remember that, immediately after the war, a hypothetical monetary operator could borrow short-term money only from banks, but he could lend short-term money to either the Treasury or banks. Under such conditions one would deposit money where there was the highest expected interest.) At the same time, as we have seen earlier, the Bank of England used to increase the interest rate to protect its gold reserves. For this reason, there existed a contradiction between the Bank’s objective of protecting the gold reserve by increasing the rates and the Treasury’s needs of a cheaper way to finance its deficit.
Basically there were three ways of "managing" the debt: running a budget surplus, consolidation of the short term debt, and increasing capital taxation. None of them proved viable as both a budget surplus and increased taxation would have jeopardized the government's fragile political situation. The consolidation of the short term debt was highly dependent on the bank rate, and the Bank of England could not afford to reduce it. The Bank of England was more concerned with restoring the gold convertibility of sterling at its pre-war level ($4.86 = 1 sterling). In the US, interest rates were higher than in the UK. Had the British bank rate been reduced, the interest rate differential between the US and UK would have encouraged the gold exports from the UK to US. In fact, the market speculated (it was extremely profitable to export gold to the US) on this possibility and the sterling exchange rate undervalued constantly the official pre-war rate. Eventually, at the end of March 1919, the Bank decided to prohibit the export of gold coin or bullion.

Despite several major increases of the bank rate, by February of 1920 the US dollar/sterling exchange rate dropped to a minimum of $3.2/pound. (As compared to its pre-war benchmark of $4.86.) At the same time, the British economic situation was unprecedented. The economy operated at the same time at full employment, high inflation, and an unfavorable exchange rate. Under these circumstances, as well as facing major difficulties in settling down the inter-allies debt (the operational debt created during the war between France, the US, and Britain), the Bank of England started periodical consultations with the New York Federal Reserve Bank. The international contacts of the Bank had as the ultimate goal "to see the monetary systems of Europe once more bound together in an international gold standard." (Sayers, Vol. 1, 1976, p. 120)
Meanwhile, the British and American authorities tried to coordinate their actions so that the interest rate differential become minimal. In April 1920, the Bank had to cut its bank rate because the Treasury had just done the same thing for the T-bill rates. In the same day, even before this decision was to be carried out, the governor of the Bank “cabled to the New York Federal Reserve governor” (Ibid., p. 124) in order to determine him to make a corresponding reduction. For a couple of years this policy of continuously informing each other about everybody’s short term intentions was effective. The speculations against interest rate differential between the U.K. and the US ceased and by April 1922, the exchange rate of US dollars dropped to around $4.45/pound.

3.2 The 1925 Return to Gold

During 1923 not only British prices were growing faster than the American prices, but an agreement had been reached on the war debt to Washington. The immediate consequence of price level differential and supplemental debt-connected pressures was a substantial depreciation of the U.S. dollar - sterling exchange rate. The Bank wanted to increase its rate, but the Treasury opposed it vehemently. First, the unemployment rate was very high. Second, industry and trade would protest in the face of more expensive credit. Third, since the export of gold was forbidden until the end of 1925, the bank rate lost much of its pre-war significance. For these reasons, it seemed that the main monetary policy objective changed from preserving the gold standard to preserving the value of money. Keynes observed this discrepancy and believed that it was due to the stubbornness of the Bank to return to the pre-war parity rate. (Collins, 1988, p. 279) The pre-war
parity rate over-valued sterling by about 10% and if it had been reinforced it would have hurt the British economy even more.

Although there were solid arguments invoked against a return to the gold standard, in April of 1925, the Bank decided to return to gold convertibility of sterling at its pre-war value. The new monetary environment imposed a withdrawal of the technical convertibility of notes into gold coins, and set a minimum of 400 ounces of gold (1700 sterling) for conversion of notes into bullion. Another concern was the concomitant existence in circulation of Treasury and Bank note issues. Because the Bank needed to know how much gold it should keep in its vaults, there was a consensus over the fact that only after two years of the gold standard the Bank would amalgamate the notes. In November 1928, the Treasury and the bank notes in circulation were merged into a single Bank note issue.

The decision to return to the gold standard at its pre-war parity was a subject of contention. The policy options of the Bank and the government were severely restricted by the fact that every single policy had to be subordinated to the needs of sustaining the convertibility. Unemployment rate, balance of payments, government deficit, and gold reserves were the major unknown of the monetary and budgetary policy implications. For instance, “once a decision had been taken, an expansion within the domestic economy to reduce unemployment rates could not be countenanced if there was any danger that this might weaken the balance of payments and endanger the reserves.” (Collins, 1988, p. 281) Friedman and Schwartz (1982) have clearly shown that once the gold standard was re-introduced in the U.K., the monetary deflation it caused damaged non-reversibly the macro-economic equilibria. The 1929-33 crisis highlighted the nature of this constraint.
Had the British authorities allowed a ten per cent devaluation of sterling in 1925, the current account would have been improved by around 70 million within three years and the unemployment rate would have been smaller with 2.4 to 3.5 % than it actually was after five years. (Ibid., p. 283) Yet, if a devalued sterling had been adopted, there were high chances that other nations would have retaliated by either increasing trade restrictions, or devaluing their own currencies.

3.3 The Crisis of 1929-1933

After the gold standard was reinstated in 1925, the Bank’s policies diversified. One of the most important new policies consisted of the Bank’s increased role in trading foreign currencies. For instance, had the interest rate increased in New York, the Bank would have sold dollars (from its own reserves) in London market to protect the flow of sterling out of Britain. Doing this, the Bank could achieve two goals.

On the one hand, it preserved its gold reserves. On the other hand, the Bank gained an additional policy tool. It did not have to only increase its rate to protect the gold reserve. (This policy became controversial mostly when unemployment rate reached high levels.) Consequently, the Bank began keeping a reserve of foreign currencies in its vaults to intervene in the foreign exchange market, should the sterling deteriorate. The Bank faced two major obstacles in using this (new) policy of controlling the gold movements. One obstacle was given by the limited amount of foreign currencies the Bank possessed. Another obstacle was the unpredictable length of the period of time the interest rate differential persisted. During the war the monetary international coordination between
France, the United Kingdom, and the United States increased but, after the war, it was not enough to prevent the individual economic crises. For example, from February to July of 1928, the New York Federal Reserve discount rate went up from 3.5 to 5 %, while the Bank of England rate stayed at 3.5. The Bank’s reaction was first to sell dollars in London, and when its dollars reserves were diminishing to allow gold to leave to or from New York and to increase its rate to 4.5%. Even so, since in New York the call rate was between 7 and 8 % this policy proved ineffective. The Bank, once again, had to manipulate gold prices to impede the gold flow over the Ocean.

In August 1929, the New York discount rate increased to 6 % and the Bank of England was facing again a monetary crisis. At the end of September the London rate increased to 6.5 %. At the end of October 1929 the Wall Street Stock Exchange collapsed. It is still debated if the interest rates increases on either side of the Ocean had something to do with the stock exchange collapse (Friedman, and Schwartz, 1982). By May 1931, the bank rate was gradually reduced to 2.5 % while the New York rate was reduced to 1.5 %. These steps proved to be insufficient in the face of a very weak U.K. trade balance which “had left London with short liabilities greatly in excess of the gold and foreign exchanges reserves in the Bank” (Sayers, 1976, Vol. II, p. 389) In May and June 1931, a series of liquidity crises took place in Germany and Austria. The foreign liquidity crises accentuated the London liquidity crisis. London tried to defend its currency against speculation expecting devaluation by taking international loans. Between July and August 1931, New York and Paris provided the Bank of England over 180 million pounds in loans to help it to defend the short term obligations.
In September 1931, Britain suspended gold convertibility of sterling. Some major factors have determined the Bank to take this drastic step. There have been three important causes behind this decision: i) the huge UK trade deficit, ii) the over-valuation of sterling, and iii) the increased budget deficit. (Collins, 1988, p. 284; Sayers, 1976, p. 387-415) The first two causes were inter-related. Had the UK reduced the gold content of sterling, the "value" of British purchases abroad would have decreased. (As I mentioned before other countries would have done the same thing.) Thus, the trade deficit could have been reduced by simply changing the gold definition of sterling. At the same time, since foreigners had more short-term claims on Britain and British investments abroad were predominantly for long terms claims "the claims on Britain could be liquidated more quickly than British claims on foreigners." (Collins, 1988, p. 288)

As far as the budget deficit, the Treasury-notes that were exchanged in 1928 for the Bank-notes put additional pressure on the money market behind the Bank's control. So long as the unemployment rate in the UK was at over 10%, the Bank hesitated to increase its rate, the bank rate had lost much of its pre-war effectiveness.

The Great Depression affected most of the world's leading economies. Income contracted, prices deflated, profits decreased, and the bankruptcies rose. Unemployment rates reached unprecedented levels. The UK felt the effects of the world recession. London lost much of its former international position.

Getting off the gold standard in 1931, the Bank of England gained the freedom to change its monetary policies much faster than under the gold standard. Although theoretically the gold standard did not give too much room for discretionary actions,
During periods with high unemployment rates the Bank had either delayed to obey the rules of the game or changed them. Until 1931, the discretionary actions of the Bank were occasionally determined by the government’s interests. After 1931, the government’s interests became the main discretionary objectives for the Bank. (Which basically meant that the Bank gave higher priority to public interest, such as unemployment or real wage.)

During the 1929-33 crisis the Bank’s collaboration with the government increased in order to attenuate the devastating effects of unemployment and price deflation.

Immediately after the suspension of gold convertibility the pound depreciated, and exports increased. France, in 1936, and the US, in 1933, followed Britain in going off the gold standard, but the lag helped Britain to encourage domestic consumers to buy domestically-produced goods. (In his period the relative sterling price of imports had increased.) During the Great Depression years the Bank and the Treasury decided to manage the exchange rate. The exchange rate floated freely but the authorities reserved the right to intervene in the supply and demand of foreign currencies at any time. This period came to be known as a “dirty float” exchange rate. (Collins, 1988, p. 296) There was established an intervention fund with the objective to “reduce the amplitude of fluctuations (of the exchange rate) without seriously influencing long-term trends in sterling’s value.” (Ibid.)

In addition to controlling the sterling’s exchange rate, the Bank of England had also used a policy of “cheap money” to encourage economic growth and diminish the national debt. If in October 1929, at the beginning of the crisis, the bank rate was 6.5% it was only 2% by June 1932. (Collins, 1988, p. 298, and Sayers, 1976, p.430) Although
many serious problems remained after 1932 the use of the “cheap money” policy stopped the decline of the economy and it encouraged the economic recovery. In 1937 industrial production reached its pre-WW II-war peak and grew at a rate of 7.8 % p.a. (Collins, 1988, p. 301)

3.4 Summary of Historical Events

October 1694 - The Crown chartered a private bank, the Bank of England, to finance the war.

1873 - Bagehot, Walter published Lombard Street: A Description of the Money Market, the first theoretical study to suggest that the Bank of England be a lender of last resort “irrespective of anything.” (Sayers, vol. 1, 1976, p. 47)

1800 - The National Bank of France was created.

1844 - Gold standard fully introduced in Britain.

1876 - The National Bank of Germany was founded.

1878 - The National Bank of Italy was created.

1877 - Treasury bills issued weekly on tenders kept by the British Treasury at the Bank of England.

1890s - The Bank of England adopts measures to encourage the money market business with the Bank in order to achieve a greater control of the market interest rates
1906-1907 - American financial panic that resulted in massive gold exports from Britain to the US. To protect its gold reserves, the Bank of England increased the bank rate to an unprecedented level of 7%.


November 1914 - The Treasury initiated long term (over 1-year) borrowing. The Federal Reserve System begun its operation.

April 1917 - The US entered the WWI.

1922 - International Monetary Conference of Genoa aimed at restoring the international gold standard and settling inter-allies debt.

1925 - Gold standard exchange rate parity restored at its pre-war level.

1929-1933 - Great Depression.

Chapter 4. The Founding of the Fed and Some Theoretical Considerations on the Altered Behavior of Interest Rate After 1914

4.1 A Brief Historical Overview of the Founding of the Fed

Between 1863 and 1913 the structure of the US banking system and its activity was mainly determined by the provisions of the National Banking Acts of 1863, 1864, and 1865. These Acts were drafted to both solve the problems of the financial system that had existed before the Civil war and to increase revenue for the North during the Civil war.

Before the Civil war, the frequency of financial panics as well as the number of bank notes
in circulation was very high. One of the most notable successes of the Acts was the elimination of multiplicity of note issue that had existed prior to the war. Yet, the major cause of financial panics (an inelastic money supply) was not eliminated. The supply of money remained greatly inelastic, and for this reason, the frequency of financial panics continued to remain extremely high. (Miron, 1986, p. 129) In order to understand lack of money supply elasticity one has to understand the tendency of the money supply to contract in exactly those periods of the year when it was needed most.

For instance, the large proportion of agriculture in national income had major economic consequences during two major seasons. One was in the spring planting season, and the other one was in the fall crop-harvesting season. During these periods not only did farmers need more currency and credit to have the seasonal work done, but corporations were required to pay quarterly interest and dividend settlements. Although the dynamics of each financial panic was different, the trigger element of every panic was the same. There was an increased demand for bank reserves that could not be satisfied for all parties simultaneously in the short run.

The events that precipitated the creation of the Fed started with the financial panic of 1907, which accelerated the passage of the Aldrich-Vreeland Act (enacted in June 1908) and the creation of the National Monetary Commission. On the one hand, the Aldrich-Vreeland Act was designed to give New York City Banks greater powers in cases of emergencies. On the other hand, the National Monetary Commission was assigned the task of studying international banking systems in order to determine the future of the American banking system. In 1910 the Commission published a report that recommended
the creation of the Federal Reserve System. In 1913 the US Congress passed the Federal Reserve System Act, and in November 1914 the twelve banks of the Fed opened for business. (Barsky, et al., 1988, p. 126)

The Fed was mainly created to eliminate seasonal interest rate fluctuations in the US by using an "elastic currency." Consequently, the Fed would introduce "appropriate movements" into the supplies of currency and high-powered money. Actually, the Fed was supposed to increase the money supply during the spring and fall seasons, when the demand for money was at its highest levels. Also, the Fed would try to eliminate the inter-regional interest rate differentials.

The effects and the timing of the Fed's actions remain controversial. The next two sections will present the main issues concerning the much debated impact of the central bank’s founding on the time series behavior of interest rates.

4.2 Interest Rate Smoothing

According to its statutes, the Fed sought to smooth nominal interest rate movements occasioned by transitory disturbances to money demand, and/or aggregate supply. In other words, the Fed tried to control nominal interest rates directly. Using basic assumptions on money demand, money supply, and a relationship between the nominal interest rate, the real interest rate, and the (expected) inflation rate, Goodfriend (1987, 1988) presented the mechanism of interest rate smoothing. Goodfriend (1988) believed that "at each point in time, the money supply rule allows the public to form a determinate expectation of the future nominal money stock." (Goodfriend, 1988, p. 229) At the same
time, the relationship between money supply and money demand would determine the nominal level of interest rate.

If the central bank pursued a future price level target (so that the inflation rate were stationary) "nominal interest rate smoothing would make the real interest rate shock move the current price level around." (Ibid., p. 229) In reality, the central bank would not be indifferent to the idea that the current price level was erratic. For this reason, a central bank wishing to "minimize price level forecast error and smooth nominal interest rates can create the necessary inflation or deflation by moving the expected future price level around instead." (Ibid., p. 231) Under such circumstances, the error variance of both price level and money stock forecast go to infinity. Despite the lack of theoretical support of Goodfriend's model "it appears that interest rate smoothing is a policy widely followed by world central banks because they believe that the financial stability it buys is worth the cost in increased price level instability." (Ibid., p. 231)

Goodfriend's model did not accommodate for either institutional or instrumental policies that could compensate for the theoretical lack of stability of a monetary system where central bank followed interest rate smoothing. In addition, Goodfriend did not consider incorporating the rational expectations theory into the interest rate smoothing theory. Assume that one anticipates that, starting with a given point, interest rates cease to fluctuate as it happened in the past, then she/he will modify the expected (future) level of both money supply and demand. As we will see in the next section, there is plenty of empirical evidence indicating that, after 1914, interest rate smoothing was practiced by the Fed.
4.3 Literature Review

Mankiw, Miron, and Weil (1987) published a very influential article related to the adjustment of expectations to a change in regime. The main focus of their study consisted of an investigation of the impact on economic decisions of the newly created economic environment that appeared in the US after the founding of the Fed. Basically, they questioned the speed with which the economy moved to a new level of rational expectations. According to the expectations theory of the term structure, the long-term level of interest rate would be related to current and expected future short-term rates. The future expected change of the present interest rate is greatly influenced by currently available information.

Had one known that an institution was supposed to eliminate the large fluctuations of interest rates, both over time, and geographically, the absolute value of future expected changes of the interest rate would have been lower. Consequently, economic decisions would have been modified by the presence of such an institution. The Fed openly asserted that it “will put an end to the annual anxiety from which the country has suffered for the last generation about insufficient money and credit...” (Ibid., p. 360)

Mankiw, et al, (1987) found that “the evidence strongly indicates that financial market participants understood the intentions of the new institution.” (p. 361) They analyzed the three-month time loan rate series available at New York banks for the first week of each month between 1890 and 1933. Between 1890 and 1910 short rates “were quickly mean-reverting and highly seasonal.” (p. 358) From 1920 to 1933 interest rates
were close to a random walk. This proves that, between 1910 and 1920, a major change in
the stochastic process generating short-term interest rates occurred.

They also tested the rational expectations theory. In addition to the three-month
rate, they used the six-month rate series to determine if the long rate included an
expectation of a future shock. Thus, a change in the stochastic process generating short
rates needed to modify the theoretical relationship between short and long rates. So long
as “shocks to the short rate were less persistent in the 1890-1910 period than in the 1920-
1933 period, the long rate should be less responsive to the short rate in the 1890-1910
period.” (Ibid., p. 359)

Because the 1910-1920 period leaves much to speculate about the causes of the
changed behavior of the stochastic process of (short-term) interest rates, the authors
performed switching regression techniques in order to determine the most likely date for
this change. They found that “the most likely date for the change in the stochastic process
of the short rate is between December 1914 and March 1915.” (p. 359) The Fed began its
operations in November 1914. The results strongly suggest that immediately after the Fed
had begun to operate, market participants fully became conscious of its role.
Consequently, a new rational expectations equilibrium point was rather quickly attained.

Angelini (1994) asserted that Mankiw et al (1987) did not fully consider some
historical events and institutional changes in the New York money market that might have
had an impact on short-term rates. The three-month data series used by Mankiw et al. “is
affected by errors” (Angelini, 1994, p. 562) for the 1908-1918 period. Fishe and Wohar
(1990) noted that in the original sources there were missing observations, reported
as nominal, or observations with other further conditional qualifications (i.e., that a commission was paid to the lender). For the 1890-1907 period the three-month data series had 72 observations which were in error, whereas for the 1918-1933 period, 19 observations were in error. (Fishe and Wohar, 1990, Table 1, pp. 970-71)

Angelini (1994) argued that the Aldrich-Vreeland Act (according to which call and time loans on the New York money market were fully collateralized) enacted after the 1907 panic, had a major role in the elimination of future financial panics and thus it deeply affected short-term interest rate behavior. For this reason, if one wanted to test for the effects of the Fed’s founding on interest rate behavior they would need to eliminate the periods of financial panics. (This is so because a simple AR model would fail to predict the occurrence of a financial panic.)

Another point made by Angelini against the “Fed effect” was the fact that during the First World War the New York money market was under the control of the Money Committee. The Money Committee permanently changed the functioning of the money market. When the war ended, the money market had already been altered and it would not be necessary to analyze a longer time frame than 1908-1918. Angelini considers that the shift in the series of the short-term interest rates between 1890-1910 and 1920-1933 subperiods might have occurred in at least two stages over the analyzed period. Mankiw et al (1987) looked specifically for only one break point in the period they considered. In conclusion, the choice of sample period has tremendous implications on testing for the “Fed effect” on the short-term interest rate behavior.
For the 1908-1918 period, Angelini (1994) showed that "there was no parameter shift in the years astride the foundation of the Fed or that a parameter shift is impossible to detect because of the low power of my tests." (Ibid., p. 564)

After this critique, Mankiw, Miron, and Weil (1994), in a reply, studied again the short-term interest rate behavior for the 1890-1933. They found that the analysis of the time series behavior of the three-month rate had to consider both the 1907 financial panic and the 1917-1919 period of administered interest rates. Also, the Aldrich-Veerland Act, passed in June 1908, "was a major step towards preventing financial panics and can indeed be considered as an initial move toward the creation of the Fed." (Ibid., p. 548)

The Aldrich-Veerland Act was supposed to expire in June 1914, but because the Fed was due to open for business in November 1914, the Act was prolonged for another year. Fishe and Wohar (1990) noted that "the U.S. Treasury, acting under Aldrich-Vreeland, issued over $382 million in emergency currency during the year following June 1914". After using an AR(1) model and F-statistic for more sub-periods that in their initial study, Mankiw et al. (1994) found that "the exclusion of data points affected by the aftermath of the 1907 panic is crucial to the finding of no structural change, and in my view is warranted by the fact that the threat of banking panics had already been largely defused by the Aldrich-Vreeland Act." (p. 551) However, the most important conclusion is that the founding of the Fed was not necessarily responsible for the changed behavior of short-term interest rates. Angelini (1994) argued for two more potential switch points: the Aldrich-Veerland Act of 1908, and the Money Committee which administered effectively the short term rates between 1917 and 1919. Subsequent empirical results will show that
in the UK, there were identified statistical signs of changed behavior of the short-term interest rate prior to the founding of the Fed, in 1914.

Miron (1986) showed that after the creation of the Fed the "frequency of financial panics and the size of the seasonal movements in nominal interest rates both declined substantially." (p. 125) In other words, he extended even further the implications of the Fed's founding in 1914. The seasonal open market policy conducted by the Fed eliminated seasonal movement in nominal interest rates and decreased the frequency of financial panics. Thus, the regular actions of the Fed were consistently anticipated by market participants, with real positive effects on economic stability. This is in contrast to R. Barro (1977, 1978) who argued that "only unanticipated changes in money have real effects." (Miron, 1986, p. 125)

For a researcher it is difficult to identify a unique neutral monetary environment in which both the anticipated and unanticipated policies can be easily distinguished. During 1914 there occurred more events than the founding of the Fed. Some had been anticipated and some not. Which of these could be held responsible for the changed behavior of interest rate observed thereafter? If the unanticipated events (the gold standard elimination or the war) prevailed, Barro and Lucas would be correct, asserting that only unanticipated changes in money would have real effects. If the anticipated events (the creation of Fed and its expected actions) were more important, the rational expectations theory would be inconsistent. Sargent (1976) suggested that the debate would be clearer if one would analyze data from two or more different policy regimes.
Miron (1986) analyzed the 1890-1933 period. He considered the occurrences of financial panics for the 1890-1914 sub-period and he showed that, although after 1914 there were several economic recessions, only during the 1929-33 crisis did the banking system experience a financial panic. Using a Bernoulli distribution he clearly showed that “the data reject the hypothesis of no change in the frequency of panics at the 99 percent level of confidence.” (Miron, 1986, p. 131) In other words, the frequency distribution of financial panics suffered a (statistically) significant disruption in 1914. A financial panic supposed a combination of bank failures, bank runs, and stock market crashes. Usually it all started with an unexpected large deposit withdrawal or a very large loan default.

A second aspect of Miron’s paper accentuates the much smaller size of seasonal movements in nominal interest rate after 1914. He used weekly data for the interest rate on stock market call loans. Also, employing the loan-reserve ratio of the whole banking system, he was able to determine that there was a reduction in the elasticity of loan supply with respect to the interest rate after 1914 as compared to the 1890-1914 period. This implied a smoother behavior of nominal interest rates after 1914. Clearly, in 1914 there was a clear shift in policy regime.

The question of direct and immediate causality between the Fed founding and the changed behavior of the short-term interest rate series has become even more controversial after an article published by Clark in 1986. Although Clark (1986) focused on deseasonalization of interest rates after 1914 in the US, he extended the analysis to more countries. He found that “interest rate seasonal disappeared in the U.S. and other countries approximately at the same time,” and in the U.S. case “interest rate seasonal
ended approximately 3 years before the seasonal movements of currency and high-powered money changed.” (Clark, 1986, p. 76) Clark used data for the call money rate, 60-90-day commercial paper rate, and 90-day time money rate, for two major sub-periods: 1890-1913, and 1919-1932. Using sample annual autocorrelations of the first differences of both short-term interest rates and currency in circulation, bank reserves, and high-powered money, (for the two sub-periods) Clark was able to demonstrate that the Fed’s manipulation of the supply of currency and high-powered money started after the seasonality of interest rate had already disappeared.

Although the Fed was created in 1914, the Fed begun the seasonal movements of currency in circulation after June 1917 and for high-powered money after September 1917. At the same time, “American interest rate seasonal came to an end in early 1915.” (Clark, 1986, p. 91) Consequently, there was a 3-year lag between the moment when the seasonal fluctuations of the short-term interest rate ended and the time when the Fed started its counter-cyclical monetary policies. “It appears that interest rate seasonal disappeared roughly 3 years before monetary policy actions intended to eliminate it began.” (Clark, 1986, p. 114)

To extrapolate his finding, Clark studied the same sub-periods using the British, French, and German open market discount rates. He found that in all countries the interest rates had a very high seasonality prior to 1914. The British discount rate tended to rise between August and November. The German rates would tend to be higher between August and December, whereas the French rates would rise between September and November. During January, the English and German rates would tend to decrease and the
same phenomenon would be observable in February in France. "Comparing the pre-war and postwar estimates, we see that the average monthly changes of each interest rate are relatively subdued in the postwar period." (Clark, 1986, p. 87)

Although interest rate seasonality seemingly disappeared concomitantly in most countries after 1914, Clark clearly rejects the idea that the Fed "simultaneously eliminated interest rate seasonals throughout the world." (Ibid., p. 90) At that time, the U.S. lacked the financial power "to export interest rate seasonality." (Ibid.) It would seem that if interest rate seasonality ceased at the same time all over the world, the Fed did not have anything to do with it.

After grouping the data in overlapping 5-year periods, Clark used a Q-statistic on the first three annual autocorrelations of the first differences of the time series. Because of the test's limitation it was impossible to pinpoint the exact time of change in seasonality. Doing this he pointed to 1912-15 "as the period when interest rate seasonals came to an end in the U.S. and Great Britain." (Clark, 1986, p. 94)

Another interesting test was performed using the basic properties of a forecasting model. According to these properties, the more seasonal is a series, the better are the chances that forecast values for that series would include a seasonal pattern. Should, all at once, that seasonality end, the forecast values would have failed more consistently to predict the actual values. This is an implicit test that assumes the building of a forecasting model for more sub-periods whose specifications does not change to accommodate for the lack of seasonality. One can estimate where the specification of the forecast model changes by looking at (say) the variance of the forecast errors for different sub-periods.
Clark used a forecasting model based on ARIMA(1,1) for the money rate and a simple random walk model for 60-90-day commercial paper rate, 90-day money rate, and British open market discount rate. He concluded that “the forecasting tests suggested that seasonality ceased in the call money rate in March 1914, in the commercial paper rate in November 1914, in the time money rate in August 1914, and in the British open market discount rate in September 1914.” (p. 102)

Although it is true that interest rate seasonality ended in both the US and Great Britain in 1914, it is not clear why. The Fed could not influence the global money market as to determine the simultaneous elimination of seasonality in the US and Britain. Clark suggested some alternative explanations. One could be the suspension of the gold standard in 1914. Another one could be the massive gold imports into the US during 1915, and 1916, and the increased supply of high-powered money.

Barsky, Mankiw, Miron, and Weil (1988) tested the influence of the 1914 dismantling of the gold standard on the changes in interest rate behavior. They analyzed US. and British rates for the 1890-1910 and 1920-1933 periods separately. "The objective is to document the change in regime in a way that avoids problems of how the transition (to a new monetary regime) took place.” (p. 1130) The series they used were three-month time loan rate for the U.S. and three-month rate on the on bankers' bills available in London. In both cases these were monthly observations, for the first week of each month.

The autocorrelation function for both subperiods and countries showed that in both countries the interest rate was mean reverting during the 1890-1910 period, and there was a significant negative autocorrelation. In the 1920-1933 period, the autocorrelations
die out less quickly. The authors also performed regressions of the interest rate on its own lagged values, including some seasonal dummies. For the 1890-1910 period, “the coefficient on the lagged short rate is significantly less than one in both countries, and there is important evidence of seasonality.” (p. 1131) For the 1920-1933 period, the interest rate was a random walk.

Barsky, *et al* (1988) integrated in their model the inflation rate and they were able to build a theoretical model for the Fed’s actions that could have changed interest rate behavior, “even if World War I and the breakdown of the classical gold standard had not occurred.” (p. 1136) The authors used switching regressions techniques and demonstrated that “both interest rates and inflation changed behavior with high probability sometime between the middle of 1914 and the middle of 1915 in both the U.S. and Britain.” (p. 1141)

Most interesting, Barsky *et al.* used the breakdown of the Bretton Woods fixed exchange rate regime in 1971 as a proof that the exchange rate regime, rather than the Fed, could not be held responsible for the altered interest rate behavior after 1914. In other words, what matters most is the behavior of the inflation rates, and the correlation across countries in inflation rather that in interest rates. As a matter of fact, the inflation correlation coefficients across the US and Britain were 38.8 % higher than the interest rate correlation coefficients for the 1890-1910 period, which were with 19.9 % higher for the 1920-1933 period. “Inflation rates shows more correlation across countries in the flexible rate period, contrary to the usual expectation based on purchasing power parity considerations.” (*Barsky, et al.*, 1988, p. 1143-5)
The breakdown of gold standard in 1914 was not accompanied by an observed change in the global linkages of prices and interest rates. Contrary to what one might have expected, the gold standard breakdown at the beginning of World War I did not modify the self-imposed restrictions of the theoretical correlation between interest rates and price levels.

Fukuda (1995) performed an analysis of the altered behavior of interest rates and inflation rates for Japan, after the founding of the Bank of Japan, in 1882. Japan was not a major international economic force either during the first World War or prior to it. Unlike the US or Britain, one cannot use Japan as an “exporter” of changes of interest rate behavior to other countries. From this prospective, the Japanese case could be taken as a benchmark.

Fukuda (1995) used the discount rate on commercial bills in Tokyo and Osaka. Data were monthly averages of daily rates. The silver standard was established in Japan in May 1885, the gold standard was legally introduced in October 1897, and the gold standard was removed in September 1914. Fukuda used a unit root test to reveal the timing in the change in interest rate behavior. The regression model was described in this case as $r_t = c + Br_{t-1}$. (Where $r =$ interest rate, $c =$ a constant term, $B =$ the parameter to be estimated, $t =$ the time period.) The estimation periods were May 1880-December 1913, and January 1920-December 1935.

Based on these historical and statistical considerations, the author discovered that after October 1897 the coefficient on the lagged interest rate was close to 1 and the coefficient on the constant term was close to 0, implying that the interest rates were close
to a random walk without drift. Before September 1897, the Z-statistic rejected the presence of a unit root in the interest rates. After October 1897, the test suggested that the unit root cannot be rejected at even 10% level of significance. In other words, the introduction of the gold standard in Japan transformed the interest rate time series from stationary to non-stationary. We have seen that much literature came to the conclusion that the founding of the Fed in the USA transformed in the same manner the short-term interest rate time series pattern. “Although our results also imply that a similar change happened in Japan, the change took place much earlier than in other countries and long before the breakdown of the gold standard.” (p. 65)

In conclusion, even if the Bank of Japan was created in 1882 the Bank did not play a crucial role in the Japanese money market until much later. Although the Bank of Japan started performing interest rate smoothing in 1885 (when the interest rate came to have highly positive autocorrelations), it was only after 1897 that interest rates changed their behavior. This is somehow surprising, but Fukuda attributes it to “the imperfections in the Japanese financial system.” (p. 71) Because in 1880s there were simultaneously in circulation government notes, national bank notes, as well as specie coins, in addition to the convertible bank notes issued by the Bank of Japan, “the degree of interest rate smoothing was very limited at the beginning.” (Ibid.) “Only after the establishment of the gold standard the reforms for the interest rate smoothing were almost completed.”

In the United States and United Kingdom, only after the breakdown of the gold standard, in August 1914, did interest rate time series change behavior. Another cause, suggested by Fukuda, for the precocity of the changed behavior of interest rates in Japan
was the fact that “Japan had a less strict gold reserve ratio objective under the gold standard.” (Ibid., p.72) Consequently, so long as the gold reserve ratio objective was weak under the gold standard, the Bank of Japan could achieve its nominal interest rate smoothing objective under the gold standard as the U.S. and U.K. could after the breakdown of the gold standard.

4.4 Summary of the Literature Review

In conclusion, there have been expressed divergent opinions about the main cause(s) that determined the changed behavior of short-term interest rate as well as when the change occurred. Clark (1986) concluded that the founding of the Fed could not be held solely responsible for the altered behavior of interest rate after 1914. Actually, he established that the Fed became actively involved in the US monetary markets after three years of existence, in 1917. In addition, he observed that the same phenomenon occurred in more countries, at around the same time. In an initial study, Mankiw et al. (1987) found the opposite thing. They analyzed monthly observations for short-term interest rate between 1890 and 1933. They concluded that the founding of the Fed was entirely responsible for the changed behavior of short-term interest rate.

Angelini (1994), and Fishe and Wohar (1990) challenged Mankiw’s statement. They found that either the data used by Mankiw et al. (1987) contained many errors or the authors did not fully consider other historical events and institutional changes. Angelini (1994) pinpointed the Aldrich-Veerland Act of 1908 and the Money Committee of 1917-1919 as potential sources for the changed behavior of short-term interest rate. Mankiw et
al. (1994) responded to these observations with a reply in which they acknowledged that indeed other factors might well have influenced the changed behavior of short-term interest rate.

Miron (1986) used an indirect measure of the Fed's implications on the US financial markets. The instability of the pre-Fed period was characterized by a statistically significant larger number of financial panics than during the post-Fed period. From this viewpoint, Miron (1986) considers that the founding of the Fed had a positive impact on the US economy. Also, he determined that after 1914 short-term interest rate had a smoother behavior. Combining these two findings, he believes that in 1914 there was a clear shift in policy regime caused be the founding of the Fed.

Barsky et al. (1988) tested the short-term interest rate behavior under both the gold standard and the free floating system. They concluded that the breakdown of the gold standard at the beginning of World War I was not responsible for the changed behavior of the short-term interest rate.

We will show that neither the founding of the Fed, nor the breakdown of the gold standard (both of which happened at around the same time, in 1914) were responsible for the changed behavior of British short-term interest rate after 1914. In the next chapter of this thesis we will analyze the time series properties of the weekly data for the British 60-day draft rate between 1890 and 1933. We will try to discover if a structural break in the series occurred, and if it did, what was (or were) the most likely cause(s).
### Table I. Summary of Literature Review

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Data and Methodology</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mankiw, Miron, and Weil (1987)</td>
<td>Monthly observations on 3- and 6-month loan rate at New York banks, (for the first week of each month) 1890-1933. Simple AR(1), autocorrelation analysis, maximum likelihood procedure, and Modigliani-Sutch relation between long and short term rates.</td>
<td>Economic agents quickly understood that the founding of the Fed changed the stochastic environment in which they were operating. More precisely, the short term interest rate behavior changed sometime between October 1914 and March 1915, only because of the Fed.</td>
</tr>
<tr>
<td>Angelini (1994)</td>
<td>Used the same data set as Mankiw, <em>et al.</em> Also employed AR(1) analysis on a restricted time frame, between 1910 and 1920. Considered historical and structural changes</td>
<td>Discovered that there are two additional potential switching points that need to be accounted for. The first point would be the financial panic of 1907 and the Aldrich-Vreeland act of 1908. The second would be the 1917-1919 period, when the Money Committee permanently altered the functioning of the American money market. The founding of the Fed had nothing to do with the altered behavior of interest rate time series.</td>
</tr>
<tr>
<td>Mankiw, Miron, and Weil (1994)</td>
<td>Replied to Angelini. As suggested by Angelini, and using the same procedures, they considered more possible statistical breakpoints.</td>
<td>The American financial panic of 1907 together with the Aldrich-Vreeland act of 1908 had indeed very significant effects on the behavior of short-term interest rates. Still, the biggest breakpoint in the time series occurred after 1914.</td>
</tr>
<tr>
<td>Fishe and Wohar (1994)</td>
<td>They employed the same series as Mankiw <em>et al.</em> Used weekly as well as monthly data. Also they corrected data errors. Used switching techniques in order to select the most likely switch dates of the time series.</td>
<td>For 3-month rates they found two switch points. One would be in August 1909 and the other one in February 1915 (for the weekly data, it would be in December 1915). For 6-month time series the breakpoint would be June 1912 (the same point was obtained when they used weekly data). The entire term structure of interest rate was not similarly affected by the founding of the Fed. There was no regime change in 1914.</td>
</tr>
<tr>
<td>Miron (1986)</td>
<td>Studied the occurrences of financial panics between 1890 and 1933. Seasonal movements of stock market call loan rates were analyzed. Also, studied the loan-reserve ratio of the whole American</td>
<td>After the founding of the Fed the frequency of financial panics and the seasonal movements of interest rates diminished. He was able to show that, compared to the 1890-1914 period,</td>
</tr>
</tbody>
</table>
banking system.


after 1914 there was a reduction in the elasticity of loan supply with respect to interest rate. This is consistent with interest rate smoothing.

Although the Fed started its activity in 1914, only starting with the second half of 1917 did the Fed begin the seasonal movements of currency in circulation and high-powered money in order to smooth interest rates. In fact interest rate seasonality disappeared between 1912 and 1915 in both Europe and the US. It is obvious that the Fed did not have anything to do with the changed behavior of interest rate. Clark suggested other possible factors, such as the suspension of gold standard, or the massive gold imports into the US during the war.

In both US and Britain, inflation and interest rates changed behavior between the middle of 1914 and middle of 1915. The gold standard breakdown in August 1914 did not influence the changed behavior of interest rates in either Britain nor the US.

Although the Bank of Japan (created in 1882) started performing interest rate smoothing in 1885, the behavior of short-term interest rate series changed only after 1897. Since the gold standard was introduced in Japan in 1897, it seems that its introduction (and not the breakdown of the gold standard) precipitated the change in behavior of interest rate time series, from stationary to non-stationary.
Chapter 5. The Behavior of the British 60-day Draft Rate, 1890-1933

5.1 Data Description

Starting with the 1880s, the Bank of England used the bank rate as the main policy instrument aimed at controlling the gold flow in and out of England. A higher British bank rate would make deposits of gold more attractive (in the form of sterling). A lower rate would allow for an export of gold to countries where the rate was relatively higher. (In theory, this mechanism would predict a stable equilibrium of gold and foreign exchange markets. In reality, there were more factors that altered the pure mechanism of the foreign exchange and gold markets, known as “the rules of the game.”) At the same time, the bank rate was used (by commercial banks) as a benchmark for discount rates which commercial banks would charge to their customers. The “60 days’ bankers’ drafts” was the discount rate the commercial banks would charge for a (commercial) draft with a period to maturity of up to 60 days.

A commercial draft is a check drawn by a bank on itself or its agent. In this instance, a person who owes money to another buys the draft from the bank for cash -and pays interest-, and hands it to the creditor who needs to have no fear that it might be dishonored. The draft was used only when a creditor did not want to accept an ordinary check (that was used mainly between well-known merchants). Since commercial banks assumed a higher than usual risk, they needed to charge the draft buyers a slightly higher rate than the rate charged ordinarily for discount operations. Moreover, commercial banks
re-discounted most of their commercial bills at the Bank of England’s counters, that used the bank rate as official discount rate.

The 60 days’ bankers’ drafts rate was determined daily by commercial banks. The bankers’ decision was based on the rate determined by the Bank of England. The Economist published weekly a special section dedicated to bank returns of European (including Britain) and North American (US and Canada) countries. In this section of the Economist one finds information about discount and loan market in Britain. Daily data were reported on the (official) bank rate, bankers’ drafts rate, market rates of discount (for three, four, and six months) used by commercial banks, interest rates for loans, and the rate for deposit allowances.

The 2296 weekly observations of 60 days’ bankers’ drafts rates (henceforth 60DR) used in this thesis were gathered from the banks’ return section of The Economist between January 3, 1890 and December 30, 1933. The rates consist of the average of the highest and lowest rates mentioned for Friday (of each week).

The data was provided to me by Professor Mark Wohar. I have thoroughly checked the data and I eliminated all data errors. Means and standard deviation were computed for both levels and differences of interest rates. These statistics are reported in Table II. Weeks in which changes in interest rates exceeded + or - 2.5 standard deviations were designated as outliers. For example, if the change between the interest rate in week 11 and week 10 was above 2.5 standard deviations then week 11 was given a dummy variable (called d11) where d11 was 1 in week 11 and 0 elsewhere. There have been identified 61 outliers (presented in Table III). Graph 1 shows the first difference of the
60DR time series, together with the + or - 2.5 standard deviation bands (including outliers).

Table II. Basic Statistics of the 60DR Time Series and First Difference

<table>
<thead>
<tr>
<th>Statistic</th>
<th>60DR Time Series</th>
<th>First Difference 60DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.1874</td>
<td>0.000523</td>
</tr>
<tr>
<td>Maximum</td>
<td>7.19</td>
<td>3.22</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.38</td>
<td>-1.5</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.444</td>
<td>0.2869</td>
</tr>
</tbody>
</table>

The presence of (all) 61 outliers is entirely explained by the changes of the bank rate levels performed by the Bank of England. As we have seen in the previous chapters, the Bank increased its rate when the export of gold would put the Bank’s reserves in danger of depleting. The Bank reduced the bank rate when the import of gold would increase.

For instance, on August 4, 1893 the 60DR increased from 1.63 to 2.88 % and a week later, the 60 DR jumped to 4.25 %. During the same period, the bank rate increased from 2 to 3 %, and then to 4 %. The Economist suggested that “the withdrawals of gold for the US have continued on a large scale, and market rates hardened, in anticipation of a further advance in the bank rate. The decision of the directors to advance the (bank) rate to 4 % was, therefore, fully expected, and the market at once responded by bringing its rates for fine paper of all dates up to and over the bank level. Somewhat unsettled
Graph 1. First Difference of the 60DR Time Series

(Horizontal Lines Represent ± 2.5 Standard Deviations)
conditions prevail, and in the event of the higher rates failing to attract gold from the Continent, where the stocks are being tightly held, it is quite possible the Bank may have to take further steps for the protection of its rapidly diminishing reserve. The Imperial Bank of Germany has advanced its rate 1 per cent.” (The Economist, August 12, 1893, p. 984)

On January 3, 1908, the 60DR decreased from 6.38 to 5 %, while the bank rate was reduced from 7 to 6 %. The Economist comments that “The reduction of the bank rate, while it had been hoped for, was hardly expected so soon after the turn of the year. Next week was regarded as the most probable date for the first reduction. It was very cordially received, being taken as an indication of a belief in the highest quarters that the worst of the American trouble is over. In the last few days of December a very large sum was borrowed by the market from the Bank, and loan rates ruled at 6.5 to 7 %.” (The Economist, January 4, 1908, p. 34)

Table III. The Outliers of the Time Series (Observations whose values changed in one week by more than 2.5 standard deviations -in absolute value-)

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Previous Value</th>
<th>Current Value</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)=(3)-(2)</td>
</tr>
<tr>
<td>1</td>
<td>July 11, 1890</td>
<td>3.38</td>
<td>4.13</td>
<td>0.75</td>
</tr>
<tr>
<td>2</td>
<td>August 1, 1890</td>
<td>3.88</td>
<td>4.75</td>
<td>0.87</td>
</tr>
<tr>
<td>3</td>
<td>September 26, 1890</td>
<td>4.00</td>
<td>4.75</td>
<td>0.75</td>
</tr>
<tr>
<td>4</td>
<td>November 7, 1890</td>
<td>4.88</td>
<td>5.75</td>
<td>0.87</td>
</tr>
<tr>
<td>5</td>
<td>December 5, 1890</td>
<td>4.75</td>
<td>3.75</td>
<td>-1.00</td>
</tr>
<tr>
<td>6</td>
<td>January 9, 1891</td>
<td>3.63</td>
<td>2.75</td>
<td>-0.88</td>
</tr>
<tr>
<td>7</td>
<td>January 16, 1891</td>
<td>2.75</td>
<td>2.00</td>
<td>-0.75</td>
</tr>
<tr>
<td>8</td>
<td>July 17, 1891</td>
<td>1.13</td>
<td>1.88</td>
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</tr>
<tr>
<td>9</td>
<td>October 30, 1891</td>
<td>2.25</td>
<td>3.31</td>
<td>1.06</td>
</tr>
<tr>
<td>10</td>
<td>December 4, 1891</td>
<td>3.38</td>
<td>2.5</td>
<td>-0.88</td>
</tr>
<tr>
<td>11</td>
<td>January 8, 1892</td>
<td>2.75</td>
<td>2.00</td>
<td>-0.75</td>
</tr>
<tr>
<td>12</td>
<td>March 4, 1892</td>
<td>2.75</td>
<td>2.00</td>
<td>-0.75</td>
</tr>
<tr>
<td></td>
<td>Date</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>13</td>
<td>May 13, 1892</td>
<td>1.00</td>
<td>1.88</td>
<td>0.88</td>
</tr>
<tr>
<td>14</td>
<td>May 20, 1892</td>
<td>1.88</td>
<td>0.94</td>
<td>-0.94</td>
</tr>
<tr>
<td>15</td>
<td>April 28, 1893</td>
<td>1.44</td>
<td>2.25</td>
<td>0.81</td>
</tr>
<tr>
<td>16</td>
<td>May 12, 1893</td>
<td>2.75</td>
<td>3.75</td>
<td>1.00</td>
</tr>
<tr>
<td>17</td>
<td>June 2, 1893</td>
<td>4.00</td>
<td>2.50</td>
<td>-1.50</td>
</tr>
<tr>
<td>18</td>
<td>June 9, 1893</td>
<td>2.50</td>
<td>1.50</td>
<td>-1.00</td>
</tr>
<tr>
<td>19</td>
<td>August 4, 1893</td>
<td>1.63</td>
<td>2.88</td>
<td>1.25</td>
</tr>
<tr>
<td>20</td>
<td>August 11, 1893</td>
<td>2.88</td>
<td>4.25</td>
<td>1.37</td>
</tr>
<tr>
<td>21</td>
<td>September 8, 1893</td>
<td>3.75</td>
<td>3.00</td>
<td>-0.75</td>
</tr>
<tr>
<td>22</td>
<td>January 5, 1894</td>
<td>2.44</td>
<td>1.50</td>
<td>-0.94</td>
</tr>
<tr>
<td>23</td>
<td>April 8, 1898</td>
<td>2.88</td>
<td>3.63</td>
<td>0.75</td>
</tr>
<tr>
<td>24</td>
<td>May 27, 1898</td>
<td>3.25</td>
<td>2.31</td>
<td>-0.94</td>
</tr>
<tr>
<td>25</td>
<td>September 23, 1898</td>
<td>1.63</td>
<td>2.69</td>
<td>1.06</td>
</tr>
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<td>26</td>
<td>October 14, 1898</td>
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<td>3.63</td>
<td>1.13</td>
</tr>
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<td>July 14, 1899</td>
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<td>3.50</td>
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<td>28</td>
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</tr>
<tr>
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</tr>
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<td>31</td>
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<td>4.75</td>
<td>3.75</td>
<td>-1.00</td>
</tr>
<tr>
<td>32</td>
<td>May 18, 1900</td>
<td>4.00</td>
<td>3.19</td>
<td>-0.81</td>
</tr>
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<td>33</td>
<td>July 20, 1900</td>
<td>2.81</td>
<td>3.81</td>
<td>1.00</td>
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<td>October 19, 1906</td>
<td>4.38</td>
<td>5.38</td>
<td>1.00</td>
</tr>
<tr>
<td>35</td>
<td>January 4, 1907</td>
<td>5.94</td>
<td>4.94</td>
<td>-1.00</td>
</tr>
<tr>
<td>36</td>
<td>April 12, 1907</td>
<td>4.44</td>
<td>3.50</td>
<td>-0.96</td>
</tr>
<tr>
<td>37</td>
<td>November 1, 1907</td>
<td>4.50</td>
<td>5.69</td>
<td>1.19</td>
</tr>
<tr>
<td>38</td>
<td>November 8, 1907</td>
<td>5.69</td>
<td>6.75</td>
<td>1.06</td>
</tr>
<tr>
<td>39</td>
<td>January 3, 1908</td>
<td>6.38</td>
<td>5.00</td>
<td>-1.38</td>
</tr>
<tr>
<td>40</td>
<td>October 16, 1909</td>
<td>2.32</td>
<td>3.38</td>
<td>1.06</td>
</tr>
<tr>
<td>41</td>
<td>March 19, 1910</td>
<td>2.75</td>
<td>3.69</td>
<td>0.94</td>
</tr>
<tr>
<td>42</td>
<td>October 1, 1910</td>
<td>2.38</td>
<td>3.50</td>
<td>1.12</td>
</tr>
<tr>
<td>43</td>
<td>October 22, 1910</td>
<td>3.19</td>
<td>4.56</td>
<td>1.37</td>
</tr>
<tr>
<td>44</td>
<td>January 24, 1914</td>
<td>3.38</td>
<td>2.63</td>
<td>-0.75</td>
</tr>
<tr>
<td>45</td>
<td>August 1, 1914 (*)</td>
<td>2.21</td>
<td>Bank closed</td>
<td>See note</td>
</tr>
<tr>
<td>46</td>
<td>August 8, 1914 (*)</td>
<td>Bank closed</td>
<td>5.37</td>
<td>See note</td>
</tr>
<tr>
<td>47</td>
<td>September 12, 1914</td>
<td>4.44</td>
<td>3.34</td>
<td>-1.12</td>
</tr>
<tr>
<td>48</td>
<td>June 26, 1915</td>
<td>2.78</td>
<td>4.00</td>
<td>1.22</td>
</tr>
<tr>
<td>49</td>
<td>November 1, 1919</td>
<td>3.69</td>
<td>4.60</td>
<td>0.91</td>
</tr>
<tr>
<td>50</td>
<td>November 8, 1919</td>
<td>4.60</td>
<td>3.69</td>
<td>-0.91</td>
</tr>
<tr>
<td>51</td>
<td>January 3, 1920</td>
<td>5.91</td>
<td>5.13</td>
<td>-0.78</td>
</tr>
<tr>
<td>52</td>
<td>February 7, 1920</td>
<td>4.88</td>
<td>5.66</td>
<td>0.78</td>
</tr>
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<td>53</td>
<td>April 17, 1920</td>
<td>5.03</td>
<td>5.88</td>
<td>0.85</td>
</tr>
<tr>
<td>54</td>
<td>October 9, 1920</td>
<td>6.69</td>
<td>5.82</td>
<td>-0.87</td>
</tr>
</tbody>
</table>
5.2 Postulated Hypothesis

The last section described how an accurate time series was obtained. In this section we will build a hypothesis based both on previous empirical works and historical events. The hypothesis is based on two major considerations. On the one hand, the founding of the Bank of England in 1694 was mainly connected with the sustenance of the Crown's war effort. As described in previous chapters, for many historical and conjectural reasons, the Bank of England's objectives changed substantially in the 1890s. On the other hand, in 1914 the Fed was founded specifically with the intention of eliminating the seasonal behavior of short term interest rates. The issues we analyze are: Did the Bank of England adopt similar objectives to those of the Fed? If this is true, then when did it begin to have objectives similar to those of the Fed? In other words, when did the Bank of England start to behave as if it were smoothing interest rates?

Mankiw and Miron (1986) could not reject the view that the short-term interest rate was a random walk after the founding of the Fed, but not before. Miron (1986) demonstrated that the Fed removed a strong seasonal fluctuation in the nominal interest rate.
rate that ranged from about 6% for the 1890-1914 period. These findings would suggest that the Fed acted to smooth interest rate behavior after 1914. Interest rate smoothing assumes that the money supply policy followed by the central bank allows the public "to form a determinate expectation of the future nominal money stock." This policy, in turn, under specific circumstances lowers the expected future nominal money stock each period. (Goodfriend, 1988, p. 229)

Nonstationary short-term interest rate time series are consistent with interest rate smoothing. It is much agreed (Clark, 1986, Goodfriend, 1987, 1988) that if we find the 60DR series non-stationary for a specific period, it is very likely that the Bank of England behaved as if it were smoothing interest rates (but without declaring it). In order to statistically test the 60DR series we use the first order autoregressive process, AR(1). In discussing the methodology of the analysis we will follow the paper of Holden and Perman (1994).

5.3 The Methodology

We consider the AR(1) process defined by

\[ r_t = B r_{t-1} + e_t, \quad t = 1, 2, \ldots \]  \hspace{1cm} (1),

where \( r_t \) stands for the 60DR at time \( t \), \( B \) would be the coefficient to be estimated, \( r_{t-1} \) stands for the lagged value of 60DR, and \( e_t \) define a variable (in sequence) of independently and identically distributed variables with zero mean and constant variance.

The process described by (1) is stationary when the estimated \( B \) is less than one in absolute value, i.e. \(-1 < B < 1\). (This is also called the stationarity condition.) If and only if
$B$ is 1, the AR(1) process described by (1) has a unit root. In this situation the AR(1) process with a unit root is non-stationary. Dickey and Fuller (1979, 1981) developed a unit root test based on the null hypothesis that assumes $B=1$, against the alternative hypothesis that $B<1$. Suppose the estimated value of $B$ is $b$. Dickey and Fuller (henceforth DF) (1979) demonstrated that the statistic $T(b-B) = T(b-1)$ has a limiting distribution. The critical values for unit root tests based on the limiting distribution for the statistic were obtained by DF using Monte Carlo simulation techniques.

The values of $r_t$ of equation (1) are estimated using ordinary least squares (OLS) techniques. For this reason, the estimation would lose much of its significance if we do not account for a constant term, past influence, outliers, and possible trend.

We subtract $r_{t-1}$ from both sides of equation, and account for outliers, trend and past influence equation (1) becomes

(2)

$$r_t - r_{t-1} = Dr_t = c + (B_1 - 1)r_{t-1} + (B_2 - 1)(r_{t-1} - r_{t-2}) + (B_3 - 1)(r_{t-2} - r_{t-3}) + \ldots + (B_w - 1)(r_{t-w} - r_{t-w-1}) + Qt + O_1r_{a1} + O_2r_{a2} + \ldots + O_k r_{ak} + e_t$$

Now, we replace $(B_w - 1)$ coefficients by $C_w$ and we obtain eq. (3)

(3)

$$r_t - r_{t-1} = Dr_t = c + C_1r_{t-1} + C_2(r_{t-1} - r_{t-2}) + \ldots + C_w(r_{t-w} - r_{t-w-1}) + Qt + O_1r_{a1} + \ldots + O_k r_{ak} + e_t$$

where $Dr$ is the difference between the level variable and its lagged value, $c$ is a constant term, $C_1$ through $C_w$ are the estimated coefficients for the number of $w-1$ lagged values of the differenced 60DR series, $t$ is the observed linear trend component for the lagged values included in equation, $O_k$ are the dummy coefficients for the $k$ outliers of the series, and $e$ stands for the random error term. Equation (3) is known as the augmented Dickey Fuller
(henceforth ADF) regression. This time, because we have differenced eq. (1) the null hypothesis becomes $H(0): C_1 = c_1 = 0$ and is tested against the alternative hypothesis $H(a): c_1 < 0$. (Lower case of $c$ means the estimated value.)

In the next section we will use the ADF regression (equation 3) for different sub-periods of 60DR time series. Based on historical considerations and previous empirical works, we hope to determine the most likely period when the stochastic processes generating the time series changed. In the historical and previous research light, we believe that the series changed its statistical behavior from stationarity to non-stationarity. Theoretically, some exogenous factors must have changed in order to alter the 60DR time series behavior. We will also try to suggest some of the historical factors that might have determined this change. Much of the literature asserted that the timing of the founding of the Fed determined the changed behavior of short-term rates in both Britain and the US. Is this true?

5.3.1 Stationarity

Equations (1) to (3) help us to determine the nature of long-run movements of economic variables. More specifically, it is necessary to establish whether random disturbances have temporary or permanent effects on the level of a variable. A variable that has no tendency to return to its mean following a disturbance is known as non-stationary. If the impacts of a random disturbance were to dampen out over time, the variable is said to be stationary. The variable could grow around a trend, (a case in which the series is known as trend-stationary). Also, the series can be viewed in terms of its
covariance over time. This is in opposition to a nonautocorrelated series which has

covariance equal to zero. Mathematically, a time series is stationary if it has a constant
mean for all time periods, and its covariance function does not depend on time.

A series is said to be integrated of order d, [I(d)], if it has a stationary invertible
autoregressive moving average representation after differencing d times. Consequently, a
series that is integrated of order zero, [I(0)], is itself stationary. The most common case of
a non-stationary series is a unit root, or is integrated of order one, [I(1)]. Equation (1)
describes a random walk process if \( e_t \) is a stationary disturbance term which is not serially
correlated. This would be a special case of a non-stationary process. If a variable evolves
according to a random walk then shocks to that variable are cumulative and not ultimately
self reversing.

A particular case would be given by equation (1a)

(1a) \[ r_t - r_{t-1} = \alpha + e_t, \] where \( e_t \) (mean zero and constant variance) is
serially uncorrelated, and \( \alpha \) is a parameter which can be considered the average predictable
increase in interest rate in each period \( t \). In this case, the time series follows a random walk
with drift. Equation (1b)

(1b) \[ r_t - r_{t-1} = \alpha + u_t, \] where \( u_t \) is stationary, describes a non-
stationary process integrated of order one, [I(1)]. (It was differenced once to be
stationary.) As we can observe, the only difference between (1a) and (1b) consists in the
condition that determine the status of the error term. If a series is integrated, then \( u_t \) is
stationary but might be serially correlated, whereas if it is a random walk, then \( e_t \) is
serially uncorrelated. It is important to mention that an integrated process of order greater than zero has a variance that tends towards infinity.

5.4 Empirical Results

Clark (1986) suggested that the Fed begun seasonal movements of currency and high-powered money during the latter half of 1917 in order to eliminate the interest rate seasonality. At the same time, interest rate seasonals in both the US and Britain came to an end in 1914. Since the Fed could have “exported interest rate smoothing” to Britain in the second half of 1917, we tested for stationarity over more intervals of the 60DR time series. Table IV includes the t statistic for the coefficients of the ADF regressions. The null hypothesis, H(0) is that a unit root exists. We conclude that before mid-1917 the series was stationary and after mid-1917, the 60DR time series was non-stationary. This would imply that the Fed’s actions could have affected the behavior of the British short-term interest rate time series at the end of 1917 or at the beginning of 1918. At the same time, in order to fortify this finding, we need to study whether the 60DR time series changed its statistical behavior earlier.

Table IV. T-statistic of the ADF Regressions for the 60DR Time Series in the Second Half of 1917.

<table>
<thead>
<tr>
<th>Intervals</th>
<th>Number of Observ.</th>
<th>Outliers</th>
<th>T-statistic for the C1 ADF Coefficients</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 3, 1890-July 7, 1917</td>
<td>1435</td>
<td>48</td>
<td>-4.09*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Aug. 4, 1917-Dec. 30, 1933</td>
<td>860</td>
<td>13</td>
<td>-2.08</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Aug. 4, 1917</td>
<td>1439</td>
<td>48</td>
<td>-4.98*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Period</td>
<td>N</td>
<td>T</td>
<td>Statistic</td>
<td>Decision</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----</td>
<td>----</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Sept. 8, 1917-Dec. 30, 1933</td>
<td>853</td>
<td>13</td>
<td>-2.23</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Sept. 8, 1917</td>
<td>1444</td>
<td>48</td>
<td>-5.12*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Oct. 6, 1917-Dec.30, 1933</td>
<td>849</td>
<td>13</td>
<td>-1.86</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Nov. 3, 1917</td>
<td>1449</td>
<td>48</td>
<td>-4.97*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Dec. 1, 1917-Dec. 3, 1933</td>
<td>844</td>
<td>13</td>
<td>-2.15</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Dec. 3, 1917</td>
<td>1453</td>
<td>48</td>
<td>-6.11*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Jan. 5, 1918-Dec.30, 1933</td>
<td>840</td>
<td>13</td>
<td>-1.99</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Jan. 5, 1918</td>
<td>1461</td>
<td>48</td>
<td>-5.84*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Feb. 2, 1918-Dec. 30, 1933</td>
<td>835</td>
<td>13</td>
<td>-1.98</td>
<td>Can’t Rej. H(0)</td>
</tr>
</tbody>
</table>

Notes: (1) The actual regressions included also a trend component. Since in none of the regressions was the trend statistically significant we ignored it. In most cases the estimated coefficients for all outliers (dummy variables) are statistically significant.

(2) At 5% level of significance the critical t value for ADF statistic is -2.86 (for a very large sample).

(3) Source: Table 8.5.2 of Fuller (1976, p. 373).

(4) H(0) is the existence of a unit root.

Mankiw et al. (1987) shows that, in the US case, the short term interest rate behavior changed in November 1914, immediately after the founding of the Fed. This fact would indicate that, in a matter of days, economic agents understood the implications of the Fed’s announced targets. In consequence, the stochastic process generating the short term interest rate time series changed.
Barsky et al. (1988) confirmed Mankiw et al.'s finding that the Fed was the main factor responsible for the changed behavior of short term interest rate time series. They also extended this conclusion to Britain. "The switch occurred with high probability sometime between the middle of 1914 and the middle of 1915 in both the US and Britain." (1988, p. 1141) Based on these works, we used ADF regression equations to test for stationarity of the 60DR time series at the end of 1914 and the beginning of 1915. Table V summarizes the t statistic for the CI coefficient of ADF regressions.

Table V. T-statistic of the ADF Regressions for the 60DR Time Series in the Second Half of 1914.

<table>
<thead>
<tr>
<th>Intervals</th>
<th>Number of Observ.</th>
<th>Outliers</th>
<th>T-statistic for the CI ADF Coefficient</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 3, 1890-July 4, 1914</td>
<td>1278</td>
<td>44</td>
<td>-4.88*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Aug. 1, 1914-Dec. 30, 1933</td>
<td>1013</td>
<td>17</td>
<td>-2.07</td>
<td>Can't Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Aug. 1, 1914</td>
<td>1283</td>
<td>44</td>
<td>-4.29*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Sept. 5, 1914-Dec. 30, 1933</td>
<td>1008</td>
<td>17</td>
<td>-2.72</td>
<td>Can't Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Sept. 5, 1914</td>
<td>1287</td>
<td>46</td>
<td>-4.34*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Oct. 3, 1914-Dec. 30, 1933</td>
<td>1004</td>
<td>15</td>
<td>-1.93</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Nov. 7, 1914</td>
<td>1291</td>
<td>47</td>
<td>-4.65*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Dec. 5, 1914-Dec. 3, 1933</td>
<td>995</td>
<td>14</td>
<td>-2.78</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Dec. 5, 1914</td>
<td>1300</td>
<td>47</td>
<td>-3.96*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Jan. 2, 1915-Dec. 30, 1933</td>
<td>992</td>
<td>14</td>
<td>-2.68</td>
<td>Can’t Rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Jan. 2, 1915</td>
<td>1304</td>
<td>47</td>
<td>-4.21*</td>
<td>Reject H(0)</td>
</tr>
</tbody>
</table>
Notes: (1) The actual regressions included also a trend component. Since in none of the regressions was the trend statistically significant we ignored it. In most cases the estimated coefficients for all outliers (dummy variables) are statistically significant. (2) At 5% level of significance the critical $t$ value for ADF statistic is -2.86 (for a very large sample). (3) Source: Table 8.5.2 of Fuller (1976, p. 373). (4) $H(0)$ is the existence of a unit root.

Since the null hypothesis of non-stationarity of the 60DR time series can not be accepted for all of the coefficients of pre-1914 intervals, we conclude that the series remained stationary before the First World War or founding of the Fed. The 60DR time series was non-stationary for all sub-periods after the second half of 1914. Once more, corroborated by previous empirical works, we need to extend our search for a break point in the series.

As we have seen, using breakpoints of either 1917 or 1914 we find that the 60DR time series changed its statistical behavior. These findings imply that the series could have changed its behavior even sometime before the events of 1914. Angelini (1994) concluded that the Aldrich-Vreeland act enforced after the American financial panic of 1907 “played a fundamental role in the elimination of panics and hence it deeply affected the behavior of short-term interest rate.” (p. 562) For this reason, we extended the ADF regression to the last part of 1907. Table VI reports the results of ADF regressions for selected intervals.
Table VI. ADF Regression Results of the 60DR Time Series for Selected Intervals of 1907 and 1908

<table>
<thead>
<tr>
<th>Intervals</th>
<th>Nr. of Obs</th>
<th>Nr. of Outliers</th>
<th>CI</th>
<th>T-statistic</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 3, 1890-Dec. 31, 1910</td>
<td>1082</td>
<td>43</td>
<td>-0.03</td>
<td>-3.78*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Jan. 7, 1911-Dec. 30, 1933</td>
<td>1200</td>
<td>18</td>
<td>-0.01</td>
<td>-2.63</td>
<td>Can't rej. H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Nov. 24, 1899</td>
<td>503</td>
<td>28</td>
<td>-0.05</td>
<td>-3.27*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Dec. 1, 1889-Oct. 25, 1907</td>
<td>413</td>
<td>31</td>
<td>-0.05</td>
<td>-3.16*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Nov. 1, 1907-May 31, 1919</td>
<td>605</td>
<td>12</td>
<td>-0.04</td>
<td>-3.5*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>June 7, 1919-Oct. 5, 1929</td>
<td>540</td>
<td>9</td>
<td>-0.01</td>
<td>-1.24</td>
<td>Can't rej. H(0)</td>
</tr>
<tr>
<td>Oct. 12, 1929-Dec.30, 1933</td>
<td>221</td>
<td>4</td>
<td>-0.03</td>
<td>-3.01*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Oct. 25, 1907</td>
<td>916</td>
<td>36</td>
<td>-0.02</td>
<td>-3.51*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Nov. 1, 1907-Dec.30, 1933</td>
<td>1366</td>
<td>25</td>
<td>-0.01</td>
<td>-3.13*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-March 6, 1908</td>
<td>935</td>
<td>39</td>
<td>-0.03</td>
<td>-3.62*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Mar. 13, 1908-Dec.30, 1933</td>
<td>1347</td>
<td>22</td>
<td>-0.01</td>
<td>-2.90*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Jan. 3, 1890-Oct.16, 1908</td>
<td>967</td>
<td>39</td>
<td>-0.03</td>
<td>-3.77*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Nov. 6, 1908-Dec.30, 1933</td>
<td>1313</td>
<td>22</td>
<td>-0.01</td>
<td>-2.92*</td>
<td>Reject H(0)</td>
</tr>
<tr>
<td>Dec. 4, 1908-Dec. 30, 1933</td>
<td>1309</td>
<td>22</td>
<td>-0.01</td>
<td>-2.79</td>
<td>Can't rej. H(0)</td>
</tr>
<tr>
<td>Jan. 9, 1909-Dec. 30, 1933</td>
<td>1304</td>
<td>22</td>
<td>-0.01</td>
<td>-2.84</td>
<td>Can't rej. H(0)</td>
</tr>
<tr>
<td>Feb. 13, 1909-Dec. 30, 1933</td>
<td>1299</td>
<td>22</td>
<td>-0.01</td>
<td>-2.81</td>
<td>Can't rej. H(0)</td>
</tr>
<tr>
<td>Mar. 13, 1909-Dec.30, 1933</td>
<td>1295</td>
<td>22</td>
<td>-0.01</td>
<td>-2.81</td>
<td>Can't rej. H(0)</td>
</tr>
</tbody>
</table>

Notes: (1) The actual regressions included also a trend component and 9 past differences, as indicated by eq. (2). Since in none of regressions was the trend statistically...
significant we ignored it. In most cases all estimated coefficients for outliers
dummy variables) are statistically significant (at 5 % level).

(2) At 5% level of significance the critical t value for ADF statistic is -2.86 (for a
very large sample).

(3) Source: Table 8.5.2 of Fuller (1976, p. 373).

(4) H(0) is the existence of a unit root. Consequently, if we cannot reject the H(0)
we assume that the series was non-stationary on that interval.

As we can see, the earliest interval when the series began to be non-stationary was
December 1908 - December 1933. Because the March 1908- December 1933 period had
an estimated t-value (-2.9) very close to critical value of -2.86 we conclude that the 60DR
time series changed behavior from stationary to non-stationary between March 1908 and
December 1908.

Results of ADF test indicate that when one includes or excludes outliers, the
interest rate is stationary (i.e. reject the null hypothesis of unit root). Thus, during the
period prior to March 1908, ADF tests are invariant to the inclusion of outliers. Contrary
to this, results for the period after December 1908 indicate that the ADF test rejects the
null of unit root when outliers are not accounted for. However, the ADF test finds the
interest rate to be non-stationary when one accounts for outliers. When one does not take
into account large changes in the series as outliers, the existence of weeks with large
changes may bias the ADF test towards finding the series to be stationary. The reason for
this is that these large changes may add a volatile component to the underlying data
generating process of a unit root. If this volatility is large enough it can mask the random
Graph 2. 60DR Time Series, January 1890-December 1933

(Shaded area represents the interval on which the series was non-stationary: December 1908-December 1933)
walk nature of the series and make the process appear stationary when subjected to standard unit root tests.

It is worth mentioning that when the ADF test was performed without either the inclusion of dummy variables accounting for outliers or trend component the results suggest a different break point of the 60DR time series. The most likely period when the stochastic process generating the 60DR time series changed from generating a stationary series to a non-stationary one would be between June 1911 and November 1911. We can observe that the statistical sensitivity of the series to the inclusion or exclusion of the outliers is relatively high.

Another way for deciding whether the 60DR time series changed its statistical behavior sometime during 1908 consists in the following rule (Holden and Perman, 1994, p. 53): for the period in which the series was stationary the estimated autocorrelations should fade away rapidly as the number of lags increases whereas for the period when the series was non-stationary the autocorrelations should decay slowly. Table VII presents a sample of estimated autocorrelation coefficients of the 60DR time series for the period between 1890 and March 1908 and for the period between December 1908 and 1933.

Table VII. Sample Autocorrelation Coefficients for the 60DR Time Series. (January 3, 1890-March 13, 1908 and December 4, 1908-December 30, 1933)

<table>
<thead>
<tr>
<th>Number of Lags</th>
<th>Sample Autocorrelation Coefficients January 3, 1890-March 13, 1908 -December 4, 1908-December 30, 1933</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.969 (0.707)</td>
</tr>
<tr>
<td>2</td>
<td>0.927 (0.666)</td>
</tr>
<tr>
<td></td>
<td>0.982 (0.857)</td>
</tr>
<tr>
<td></td>
<td>0.960 (0.822)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
</tr>
<tr>
<td>3</td>
<td>0.883 (0.639)</td>
</tr>
<tr>
<td>4</td>
<td>0.841 (0.646)</td>
</tr>
<tr>
<td>5</td>
<td>0.801 (0.609)</td>
</tr>
<tr>
<td>6</td>
<td>0.765 (0.598)</td>
</tr>
<tr>
<td>7</td>
<td>0.731 (0.535)</td>
</tr>
<tr>
<td>8</td>
<td>0.7 (0.562)</td>
</tr>
<tr>
<td>9</td>
<td>0.67 (0.539)</td>
</tr>
<tr>
<td>10</td>
<td>0.643 (0.504)</td>
</tr>
<tr>
<td>12</td>
<td>0.602 (0.494)</td>
</tr>
<tr>
<td>24</td>
<td>0.383 (0.368)</td>
</tr>
<tr>
<td>36</td>
<td>0.352 (0.353)</td>
</tr>
<tr>
<td>48</td>
<td>0.458 (0.404)</td>
</tr>
<tr>
<td>60</td>
<td>0.378 (0.343)</td>
</tr>
</tbody>
</table>

Notes: a) The estimated values of the autocorrelation coefficients are all statistically significant at 1% level of significance. (Q-Statistic)

b) In parentheses are the autocorrelation coefficients that account for dummy variables (outliers).

We can observe that in the period after December 1908 the estimated autocorrelation coefficients fade away quicker as the number of lags increases compared to the period before March 1908. Graph 3 and 4 show that for a longer than 36-period lag the autocorrelation coefficients for the second period faded away faster than for the first period. The long fade away period and the cyclical period of the autocorrelation
Autocorrelation function of R, sample from 1 to 967

Graph #3 Sample Autocorrelation Coefficients
January 1890-March 1908
Autocorrelation function of $R$, sample from 1 to 1313

GRAPH. #4 SAMPLE AUTOCORRELATION COEFFICIENTS
December 1908-December 1933
coefficients for the first period suggests that, between 1890 and 1908, the 60DR time series had a long memory. Although this fact does not indicate that the series was not stationary over the 1890-1908 interval, it does indicate that the series was extremely sensitive to shocks.

If a time series with unit root (or non-stationary) were shocked, the shocks would persist forever. If a time series, instead, follow a stationary process this suggests that a shock would persist a certain (finite) time only. The duration of the shock persistence would vary from case to case but the series would eventually absorb the shock. (The values of the series would revert to a long-run mean.) Graph 3 suggests a very long absorption time of shocks by the 60DR time series. The persistent nature of time series and its implications on the AR(1) models have been studied using the Fractionally Integrated Autoregressive Moving Average models. (Choi and Wohar, 1994) According to the Fractionally Integrated models the unit-root hypothesis is a special and restrictive case of a time series. Long-memory processes are stationary.

The 60DR time series was generated from a stationary process between 1890 and the beginning of 1908, but its autocorrelation function decays much more slowly than that from “classical” stationary processes. This finding, as we have seen earlier, is consistent with “a stationary process with a long memory.” (Choi and Wohar, 1994, p. 919) A long memory process has the ability to display significant dependence between observations widely separated in time.
5.5 The 1907 American Crisis and the Bank of England

Prior to the First World War, Britain was the leading global economic force. It is hard for one to believe that the US economic crises could have had a big impact on the London decision makers. Nevertheless, economic connections between Britain and the US were strong enough to determine a crisis or a boom to be easily transmitted from either Britain to the US or vice versa. Moreover, the monetary systems of both Britain and the US were based on the gold standard, whereas the monetary (institutional) structure of Britain was different from the monetary structure of the US.

The British and American convergence of monetary goals (Britain and the US wanted to maintain the gold standard) and divergence of monetary means (due to the fact that Britain had a central bank, but the US did not) had more implications. First, since there were strong ties between the British and American economies, a situation of crisis in the US would tend to spread to Britain. Paradoxically, because of institutional differences between Britain and the US, a situation of crisis in Britain would tend to spread over to the US slower than a US crisis spread to Britain.

Secondly, due to the monetary institutional differences between Britain and the US, when a crisis began in the US, Britain reacted promptly to protect the gold standard. As we have seen earlier, in such situations, the method used most by the Bank of England was the increase of the bank rate. Contrary to the US, where in cases of financial crises interest rates would increase suddenly, in Britain the increase of the bank rate was gradual. The Bank not only decided weekly whether or not to change its bank rate, but it also "became much more tender in its attitude towards trade and industry." (Morgan, 1965, p.
Consequently, after the 1907 American crisis, the Bank of England acted as if it intended to smooth interest rates.

Thirdly, after 1907, the Bank of England diversified its monetary policy tools. The most non-conformist one was the direct operations in the gold market. The Bank would raise the buying price of bullion, raise the selling price of gold bars, manipulate the buying and selling price of foreign coin, and it even made interest-free advances to gold importers. Occasionally, in order to protect the gold reserves, the Bank imposed on the market a higher interest rate without increasing its bank rate. (Administratively, sometimes, the Bank charged a higher rate for advances than for discounts, or it discriminated against certain types of bills.) The new monetary tools used by the Bank were designed at both protecting the domestic economy and the gold standard. More specifically, the Bank did not want to harm the economy by increasing the bank rate.

Clark (1935) recognized the determinant role of London for the financing trade of the US at the beginning of the 19th century. "In the matter of foreign exchange and foreign trade financing the US were for the most part dependent upon the London money market. The US foreign trade was largely financed abroad. There was no power for the New York money market to exert a decisive influence on gold movements by means of money rate changes or the settling of international balances by offering bankers’ acceptances. “ (Clark, 1935, p. 15-16)

On October 22, 1907 the Knickerbocker Trust went bankrupt and cash payments were suspended “practically throughout the American banking system.” (Morgan, 1965, p. 222) Immediately, because American banks needed cash, gold began to flow out of
Britain to the US and the Bank of England increased its (bank) rate from 5.5% in October to 7% in November 1907. The Aldrich-Vreeland act of June 1908 was highly praised by the British media and the most influential economic magazine of the time believed that "it would undoubtedly be a means of providing relief in the event of acute monetary stringency." (The Economist, June 13, 1908, p. 1245) Not only the media was favorable to the new American currency act, but also the Bank's officials believed that the act "would help British commercial banks, in case a similar panic occurred in New York."
(Ibid., p. 1138)

The Bank of England never declared (publicly) that starting with a certain period it would change its main monetary policy goal from protecting the gold reserves to smoothing interest rates. This fact would suggest that after 1908, when the monetary environment changed not only in the US, but also in Britain, the Bank of England gradually came to alter the target of its monetary policy.

We have seen that the 60DR time series became non-stationary after December 1908. Researchers also agree on the theory that the non-stationarity of the interest rate would be consistent with interest rate smoothing employed by central banks. At the same time, our finding is compatible with the rational expectations theory according to which only unannounced (or unpredicted) events can change (persistently) economic behavior.

**Conclusion**

Previous works suggested that the founding of the Fed or the breakdown of the gold standard in 1914 would have been the main responsible cause for the changed
behavior of short-term interest rate time series for both the US and Britain. Using ADF tests, our results imply that the British 60-day bankers' draft rate time series changed its statistical behavior sometime between March 1908 and December 1908. Between 1890 and March 1908 the series was stationary (with possible long memory). Between December 1908 and December 1933 the series was non-stationary (we could not reject the hypothesis of a unit root). Historically, the March 1908-December 1908 period coincides with the end of the American financial panic of 1907 and with the adoption of the Aldrich-Vreeland act in June 1908. Although it is not very clear how the American crisis affected so much the monetary goals pursued by the Bank of England, it seems the only plausible cause.

At the beginning of the financial panic of 1906-7 American banks were facing a very severe liquidity crisis. Since the American banks badly needed cash, they were willing to borrow from British commercial banks at much higher rates than the British banks could lend to domestic customers. The British commercial banks, in turn, would buy gold from the Bank of England and would ship it over to the American banks. To protect its gold reserves, the Bank of England increased the bank rate. The Bank believed that commercial banks would be deterred from borrowing money from the Bank and buying gold with it (at the official rate). Despite the high level of the bank rate, the gold continued to be massively exported to the US during the 1906-7 crisis.

The American crisis peaked in October 1907. By March 1908 the financial crisis was over. To prevent a future crisis, in June 1908 the US Congress passed the Aldrich-
Vreeland act. The act granted special emergencies powers to New York City banks and created the National Monetary Commission. (Miron, 1986, p. 131)

The timing of the 1907 American crisis and the passage of the Aldrich-Vreeland act coincides entirely with the period when the behavior of British short-term interest rate time series changed. We believe that the massive export of gold from Britain to the US during the 1907 crisis determined the Bank of England to follow more closely the seasonal movements in domestic money demand. At the same time, the Aldrich-Vreeland act increased the financial stability of the American banking system. As a consequence, American commercial banks ceased to borrow "emergency money" from British banks. After 1908 the Bank of England did not have to worry so much about protecting its gold reserves since the American banks were required to meet the unexpected withdrawal demands with their own permanent reserves.

According to Clark (1986) the Fed begun interest rate smoothing in the last part of 1917, while the (American) short-term interest rate time series became non-stationary in the last part of 1914. Angelini (1994) argues that the US short-term interest rate time series became non-stationary in 1908, after the enforcement of the Aldrich-Vreeland act. In consequence, it seems that the Fed activity (per se) did not influence the behavior of short-term interest rate time series. In addition, Fukuda (1995) shows that the founding of the Bank of Japan did not alter the behavior of interest rate time series in Japan. Contrary to the models of interest rate smoothing, the changes in the behavior of interest rates were gradual.
We have seen that the founding of the Fed had no effect on the behavior of British short-term rates. We also determined that the American financial panic of 1907 seems to have changed the banking environment both in the US and Britain. After 1908, the increased stability of the American banking system eliminated much of the London money market pressure. For this reason, the Bank of England could better distinguish between domestic and foreign monetary crises. Consequently, the Bank of England begun to follow more closely the seasonal movements of domestic interest rates. Although the Bank of England never declared openly that it would supply “elastic currency” to the economy, the evidence presented in this thesis suggests that after March 1908 the Bank started to smooth interest rates.

6.1 Future Research

In order to better understand the connection between central banking and interest rate behavior, future research need to extend the analysis of when the behavior of short-term interest rates changed for both more interest rate time series and for different countries.

Prior to the First World War, the economic relations between the US and Britain were, in many respects, peculiar. First, Britain had prime interests in the US economy. Secondly, there existed some major structural differences between the US and British economies. Due to structural differences, Britain was more vulnerable to American economic crises than the vice-versa. For these reasons, the study of interest rate behavior
needs to be extended to more European countries, where central banks had been in place before the American crisis of 1907.

The works of Fukuda (1995) and Angelini (1994) revealed that, in the Japanese and (restricted) American case, the behavior of short-term interest rates changed independently of the time when the central banks were founded. In the Britain case we have shown that the 60-day bankers' drafts time series changed its statistical behavior in 1908, long before the Fed was founded in the US. Yet, we could not demonstrate that the British interest rate behavior was the result of (only) domestic monetary policy. For this reason, more studies need to be done on the French, German, and Italian short-term interest rates behavior, countries in which, decades before 1908, there had existed central banks.
References


