Research Unit for Statistical and Empirical Analysis in Social Sciences (Hi-Stat)

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November 2012

Hi-Stat Discussion Paper

HITOTSUBASHI UNIVERSITY

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Abstract

Using a Markov-switching GARCH model this paper analyzes the volatility evolution of the greenback's price in gold from after the Civil War until the return to gold convertibility in 1879. The econometric inference associated with our methodology indicates a switch to a regime of low volatility roughly seven months before the actual resumption. Since this empirical finding is most likely to be reconciled with a change in market expectations, we conclude that expectations affected the exchange rate more than fundamentals. Our analysis also demonstrates that regime switches in the volatility of exchange rates may reflect historical events that remain undiscovered otherwise.

Keywords: US monetary history, 19th century, greenback, Markov-switching GARCH models

JEL-Codes: N11, E42, E52, C32

I

The Civil War was not only a decisive moment in American history but also a fundamental turning point in financial development. The return to the gold standard constituted an important signal to financial markets worldwide since this monetary regime was appreciated by almost all major countries until World War I and ultimately let the US dollar inherit the role of the leading world currency from the British pound. However, within the U.S. bullionists and inflationists fought a fierce political battle over the expected distributional consequences of either monetary regime.

In this paper we study the period between the end of the American Civil War and the return to gold in 1879 and contribute to the theoretical debate on the factors that may drive exchange rates. In the literature covering this debate two opposing opinions predominate. On the one hand, monetarists like Friedman and Schwartz (1963) argue that exogenous macroeconomic fundamentals like money supplies, price inflation and price parities cause the high premiums on gold. This view is supported, *inter alia*, by Kindahl (1961), and Officer (1981). On the other hand, Calomiris (1992; 1988; 1985) strongly opposes this view by stating that expectations are more important to the greenback exchange rate than the classical fundamentals (like money supplies). Consequently, Calomiris supports the research pursued, among others, by Mitchell (1903) and Willard et al. (1996) who attempt to incorporate news and significant events in their study of the greenback markets. However, besides these opposing views other authors (e.g. Smith and Smith, 1997) argue that both expectations and macroeconomic fundamentals did play a role in the evolution of the greenback exchange rate.

In this paper we make contributions to both the financial history of the U.S. and to the debate on the factors that drive exchange rates. To this end we implement a so-called Markov-switching GARCH model that has recently emerged in the macrofinance literature (see for example Wilfling, 2009) and which enables us to analyze time-varying conditional variances of daily greenback-gold exchange rates.

More explicitly our methodology helps us to identify distinct phases (regimes) of high and low exchange-rate volatility. Since such distinct exchange-rate volatility regimes can easily be reconciled with market participants' expectations on future changes in the exchange rate (rather than with changes in fundamentals), we interpret our results as empirical evidence that agents had anticipated the exchange-rate fixing associated with the return to the gold standard beforehand. In particular, our econometric analysis detects a regime switch from high to low exchange-rate volatility several months before the actual resumption thus supporting Calomiris' view that expectations may have mattered more than macroeconomic fundamentals. Our econometric technique also provides a new means of gauging the Civil War and the postbellum period. Initially, from a financial investor's perspective, our results reflect the considerable political uncertainty that characterized the postbellum years. However, the switch to a low volatility regime long before the actual resumption date demonstrates that policy makers were surprisingly able to commit to their announced resumption plan.

This paper contains 6 sections. In Section II we briefly review the historical background for which we rely on some of the established historical literature (e.g. Mitchell, 1903; Friedman and Schwartz, 1963; Unger, 1964). Section III

presents our data set. In Section IV we specify our econometric model in the form of a two-regime Markov-switching GARCH model. Section V presents the estimation results while Section VI offers some concluding remarks.

II

Before the Civil War the U.S. money supply consisted of gold and silver coins, copper pennies and notes issued by state or private banks. All non- specie money could principally be converted into gold. There was no paper money issued by the government. However, the U.S. was practically on a gold standard since the relative price of gold to silver was higher than the world- market price so that not many silver coins were in circulation. Unlike today, there was no strong banking and currency system and no Federal Banking System in the U.S. More than 1,600 state banks existed all over the country and more than 7,000 different kinds of bank notes were in circulation the half of which carried no real worth.

At the beginning of the Civil War the Unionist government encountered difficulties in selling sufficient bonds to finance its war efforts, which lead to the suspension of specie payment by private banks and the government on December 30, 1861. This was partly due to the increased war expenditures and the low confidence in public securities and to some extent to the lack of confidence in the government and the prospects of the war. These were gravely tampered by the danger of a war with the United Kingdom because of the Trent affair (an incident in which two Confederate envoys were captured from the British Mail steamer Trent). The government reacted by issuing an inconvertible currency which became rapidly known as the 'green- back' to cover war expenditures. Three Legal Tender

Acts in February 1862, July 1862, and in January 1863 put around $450 million greenbacks into circulation.

However, since transactions with foreigners and the payment of customs duties and tariffs required gold, greenbacks did not constitute a perfect substitute for gold dollars. Consequently, a market emerged soon after the green- back issuance and the greenbacks depreciated from par, the main reasons for the depreciation being the increased demand induced by the government's war spending, the expansionist fiscal policy, negative trade balances and also war news. Bad news induced hoarding in an expectation of a higher gold price while good news prompted people to sell gold in anticipation of declining prices. Nevertheless, contemporaries believed this to be a temporary measure and the parity to be restored after the war, although nothing had been specifically declared. Meanwhile, greenbacks served as legal tender in most parts of the country where prices were quoted in greenbacks and gold was valued at its current premium market price. Only at the West Coast prices were quoted in gold and discounted to greenback prices at the current market value.

The time after the Civil War saw a huge decline in commodity prices which may be ascribed to the contraction efforts undertaken by the Secretary of the Treasury, Hugh McCulloch. These efforts were affirmed by the Congress in December 1865, but later restricted by the Congress in April 1866 and finally completely ceased in 1868. In addition, 'natural growth' reduced price levels as the money stock was held fairly stable.

Three legal decisions in 1868 reduced the role of greenbacks in business transactions. (1) In Lane Country vs. Oregon it was ruled that state taxes could

only be paid in specie, but not in legal tender notes. (2) In Bronson vs. Rhodes the Supreme Court decided that contracts demanding payment only in specie were legal. (3) In Bank of New York vs. Board of Supervisors the state was denied to levy property taxes on state notes which meant that the court did not consider them as money. The decision about the legal status of greenbacks was engaged by the Supreme Court in 1869. Initially it was ruled under Chief Justice Chase (who himself at that time had issued the Legal Tender Acts) that greenbacks had no legal tender status for contracts before the Legal Tender Acts. Owing to the accession of two new members to the court, this decision was reversed in 1871 when it was ruled that the government had the right to issue legal tender notes. However, the issue was not settled before 1884 when it was ruled that the government was eligible to do so also in times of peace. The government's commitment to debt payment in coin was shown when President Grant came to power and the gold-payment bill was enacted – which obliged the government to pay its debt in specie.

In the fall of 1873, the railroad boom suddenly came to an end and the subsequent banking panic marked the beginning of a crisis in most parts of the country. For the rest of the decade the currency problem and the conduct of financial policy became the issues of major public and political concern. President Grant was cautious in following either expansionary or contractionary monetary stances, an attitude that deeply confused the public opinion. Mixon (2006), for example, reports that the business community characterized the situation as 'frustrating, uncertain, and unclear, and the finger of blame is clearly pointed at the government.'

After a period of controversial debate the Inflation Bill finally emerged in

1874. The bill was to provide for additional national bank note circulation and to return to the $400 million of greenbacks which had circulated before the contraction measures in the 1860s. It was intended to resume specie payment on January 1, 1876. Although a rather modest measure, it represented a retreat from the resumption policy and therefore conservatives appealed to Grant to veto the law. On April 22 Grant gave his veto to the bill which for the public opinion came like a 'bombshell.' In the aftermath, the Republican Party fell into a state of great disunity and for the first time since 1861 the Party lost the majority in Congress. Therefore, the Republicans were eager to restore their unity and enacted the Resumption Act during the lame-duck session after the congressional elections in 1874. Fearing another presidential veto and the upcoming presidential elections, the Republican Senatorial caucus tried to realign inflationists and conservatives on a compromise that both sides could accept. In the wake of this free banking was introduced as a major concession to the soft money faction and inflationists since it allowed controlled inflation and a promotion of the national banking system. In addition to this, $80 of greenbacks were to be redeemed in exchange for each $100 bank note until only $300 million were supposed to be left. Resumption was proposed for January 1, 1879. Compared to the vetoed Inflation Bill the proposal itself did not constitute a real innovation, but the resumption was put exactly three years later on January 1, 1879 and many observers did not assess this decision as final.

Although the Presidential Election in 1876 loomed dark over the country and the Republican Party, it was finally decided by aspects like railroad issues and patronage. After Rutherford B. Hayes, the Republican candidate, had won by a

margin of one electoral vote the White House was commanded by a Republican, the House of Representatives by the Democrats, while the Senate was in a stalemate. Hayes, a well-known sound-money representative, appointed John Sherman as Secretary of the Treasury. Sherman, from then on in charge of the accomplishment of resumption, believed that he needed at least an amount of gold large enough to be able to redeem 40 per cent of the outstanding greenbacks. This appeared to be a difficult task since at the same time Germany and France were in dire need of gold themselves. He proved to be up to the task by offering bonds with higher interest rates to foreigners and prevented a critical drain on the money market by increasing deposits in national banks. An attempt to repeal the Resumption Act passed the Congress, but was declined in the Senate by one vote. The Bland Allison Acts of 1877 and 1878 and the Coinage Act in May 1878 constituted the final attempts to avert resumption, but did not endanger the resumption policy or change the legal commitment to resume specie payment on January 1, 1879. The crop failures in Europe injected large amounts of gold into the U.S. and activated the U.S. trade balance from 1876 onwards. Sherman secured this inflow of gold by selling gold bonds and by November 1878 he had built up a gold reserve of around $141.9 million. The premium on gold fell constantly and on December 17, 1878 par had been reached for the first time since 1862. In the days after resumption only a few notes were redeemed and in fact more gold was exchanged for paper money. Although this might be considered as a victory of the hard money faction the issue had definitely not been settled yet. More than $346 million wartime greenbacks and an annually increasing amount of silver certificates still threatened the gold standard. The reserve of around $100 million gold dollars

could only maintain the gold standard as long as the country remained prosperous and the important task of the subsequent government was to secure the gold standard. However, Calomiris (1992) demonstrates that fear about inflation remained by reporting expected inflation rates to be higher than real inflation rates. In a similar vein, Studenski and Krooss (2003) perceives the risk that silver could be used to pay government obligations and that gold could be drawn from the Treasury reserves and exported.

<p style="text-align:center">III</p>

For about two weeks after the suspension of the gold standard there was no official market for gold in New York. People willing to buy or sell gold needed to appeal to foreign coin dealers until this business became too voluminous to be conducted in such an unorganized way. The first organized gold trading started at the New York Stock Exchange on January 13, 1862. A competing trading place was established in a 'dingy cellar' in William Street dubbed the 'coal hole' (see Mitchell, 1903). As the business became larger the market moved first into the Gilpin's News Room, later into the old stock board at No. 24 Beaver Street, and finally into New Street next to the Stock Exchange. The traders in this market started referring to it as the 'Gold Room' and were content with the loose organization. It was not before October 1864 that a constitution and by-laws were adopted and regular officers elected. It is noteworthy that trading gold for other than commercial reasons at the New York Stock Exchange was considered unpatriotic or a bet against the Union's victory. This appeared in contrast to the Gold Room where speculations were not shunned at (see Nugent, 1968).

The transaction volumes in these and in two other markets were reported to be large. Importers and exporters had to change paper currency and gold to buy and sell goods, but also tried to protect themselves against fluctuations of the currency's value while awaiting the execution of their contracts. In fact, Mitchell (1903, pp. 182-185) believed that the volume of speculation exceeded normal transactions by far. However, speculators were not cherished by everyone as clarified by Willard et al. (1996) quoting Abraham Lincoln's dictum on gold market traders: 'I wish every one of them had his devilish head shot off!'

Since the prices from the New York gold markets were telegraphed to all other important U.S. cities and regarded as authoritative, we neglect prices from other cities. First sources of our data are financial columns of daily papers like the Hunt's Merchant Magazine, the Bankers' Magazine or the Commercial and Financial Chronicle. Typically, these sources report daily highest, lowest, and closing prices. There are similar tables from the Chamber of Commerce of the State New York as well as yearly published almanacs by other newspapers. However, the main source were the detailed reports by J.C. Mersereau, Register of the Gold Exchange, who published an annual book called 'American Gold, 1862-(date of issue)'. This book gave the quotations from 10 a.m. until 3 p.m. for every quarter of an hour.

All sources combined did not deviate by much and Mitchell (1908) checked them for typos. He collated the data based on Mersereau's latest issue from 1878 with the tables from the Commercial and Financial Chronicle from which he took the data for the last year 1878. Finally, the first two weeks were taken from New York's daily papers so that the complete data set contains 5,170 daily

observations of the greenback/gold dollar exchange rate for the whole period from 1862 until 1879. The exchange rates are given in indirect quotation meaning that $100 greenback were exchanged for a given sum of gold dollars. For example, on January 2, 1863 $100 greenback were exchanged on average for $74.77 in gold. Mitchell (1908) compiled all his data in the book 'Gold, prices, and wages under the greenback standard'.[1]

Figure 1 displays the golddollar/greenback exchange rate between 1862 and 1879. In mid-1864 the exchange rate dropped to only 37% of its face value and steadily recovered afterwards. The first vertical marking represents the end of the Civil War around April 9, 1865 while the second marking shows the enactment of the Resumption Act on January 14, 1875.[2]

Figure 2 about here

Figure 2 displays the evolution of the golddollar/greenback exchange rate during the years 1874 to 1879. The reason for considering this shortened time interval is that we aim at locating the switch to a regime of low volatility around the announcement date January 14, 1875. Shortly after Grant's Veto the greenback's value appreciated, but then again fell steadily for several months (see the first vertical marking). Overall, this period was characterized by high uncertainty about the upcoming financial policy and possibly financial market participants were

initially relieved that the Resumption Act was considered to be an inflationist measure in the short run. The second vertical line marks the day of the Resumption Act on which the greenback price fell. The price went on falling and remained low for more than six months before it suddenly peaked in September 1875. The exchange-rate dynamics directly following the Resumption Act may be interpreted as evidence that in the beginning the resumption did not affect financial markets substantially.

The third vertical marking represents Hayes's victory of the presidential elections. From then on the exchange rate appears to be trending upwards. Although Unger (1964) reports that the financial question had not been of major public concern during the elections, we interpret this exchange-rate dynamics as evidence that Hayes' hard money reputation actually affected the time series.

In spite of their political relevance the last three events represented by vertical markings did not affect exchange-rate dynamics considerably. The failure of repeal in 1877 had the potential to be the decisive hit against sound money opposition and it appears that the appreciation was only delayed by this decision in favor of the resumption. The steps taken later in 1878 had no substantial effect on the legal commitment of resumption so that the greenback steadily continued to trend upwards towards par.

Figure 3 about here

Figure 3 displays the daily exchange-rate returns defined as $100 \cdot [\ln(x_t) - \ln(x_{t-1})]$ for the time between June 1, 1874 and December 31, 1879 amounting to a

total of 1394 observations. Mere visual inspection of the return series reveals a regime of declining exchange-rate volatility beginning in spring 1878 with the returns falling to an extremely low level several months before the resumption. The mean of the exchange-rate returns appears to fluctuate randomly around zero.

In a first preliminary statistical analysis we split the whole sample into two equally large portions and compared the means and the standard deviations of both subsamples. While the two subsample means only differ slightly from each other, the standard deviations of both subsamples are given by $\hat{\sigma}_1 = 0.21$ and $\hat{\sigma}_2 = 0.15$ and appear to be significantly different from each other. This difference in the standard deviations becomes even larger if we modify both subsamples by considering the first subsample ranging from June 1874 until April 1878 and the second subsample ranging from May 1878 until December 1878. In this case both standard deviations are given by $\hat{\sigma}_1 = 0.20$ and $\hat{\sigma}_2 = 0.067$ hinting at a low volatility regime at the end of the sample, a finding that is consistent with our conjecture described above.

IV

In this section we provide an explanation for why we expect to find distinct volatility regimes in the nominal golddollar/greenback exchange-rate data described above. Our explanation rests on the fact that the return to the gold standard marked a transition between two alternative exchange-rate systems. Before the return to gold the exchange rate floated freely reflecting changes in the relative supply-to-demand conditions of the currencies involved while the return to gold represented the introduction of a system of completely fixed rates.

Bearing this transition in mind we invoke the existing literature on exchange-rate dynamics under alternative exchange- rate systems and under consecutive international monetary regimes which provides a theory-based motivation for switching volatility regimes in our time-series data.

Several authors have analyzed a transition from a system of floating exchange rates into a fixed-rate system on a given future date and at publicly announced fixing-parity. Under rational expectations, the mere knowledge in the market that the presently floating exchange rate will be irreversibly fixed in the future does affect the exchange-rate dynamics prior to the fixing. Theoretical models of exchange-rate dynamics under such a scenario have been developed by Miller and Sutherland (1994), Sutherland (1995), DeGrauwe et al. (1999) and Wilfling and Maennig (2001). Although focusing on different aspects, all papers derive the same unambiguous result: at that moment when the authorities publicly announce the future exchange-rate fixing the spot rate jumps from its floating-path onto an interim-path which assures an arbitrage-free transition into the fixed-rate system.

The analytical form of the interim-path crucially hinges on the political and institutional framework during the run-up to the fixed-rate system. However, Wilfling and Maennig (2001) analyze a setting in which foreign exchange market participants may be uncertain about the authorities' adherence to the publicly announced fixing date, that is, in which agents take account of the fact that the beginning of the fixed-rate system may be delayed. Two results concerning (conditional) exchange-rate volatility along the interim-path are apparent from their model. (1) The mere announcement of future exchange-rate fixing reduces exchange-rate volatility along the interim path. This volatility reduction is certain,

even in a setting with market uncertainty about the punctual entrance into the fixed-rate system. Only in the absolutely extreme case in which agents believe that the fixed-rate system will never be implemented, exchange-rate volatility remains unaffected by the announcement. (2) The volatility reduction along the interim-path is maxi- mal when agents assess the political announcement as fully credible, that is, if they are convinced that the exchange-rate fixing will occur punctually at the previously specified future date.

Overall, an essential feature of the Wilfling and Maennig (2001) model is that there are two extreme volatility regimes during the run-up to the fixed- rate system: (1) an extreme high-volatility regime, during which agents are either not aware of the future exchange-rate fixing or believe that the fixed- rate system will never be implemented, and (2), an extreme low-volatility regime during which agents are absolutely convinced that the exchange- rate fixing will start according to schedule. Apart from the economically well-grounded statements on the distinct volatility regimes, the Wilfling and Maennig (2001) model rests on an assumption that may appear unrealistic at first glance. Their model assumes that there is a clear-cut date (the so-called announcement date) at which the future exchange-rate fixing is announced and that this announcement comes as a surprise to market participants. In reality, however, inspired by political debates and perceptible institutional processes, agents frequently form expectations about the punctual fixing long before any definite official announcement.

A straightforward way to overcome this inconsistency is to reinterpret the announcement date from the theoretical model as the date-of-first-notice, that is, as the date at which market participants perceive a potential future exchange-rate

fixing for the first time. Starting from this date, agents deem a shift from presently floating to fixed exchange rates possible and continuously assess the likelihood that the fixing will occur punctually at the given date. This phase of uncertainty revisions will typically last for a while until market participants are absolutely convinced that the exchange-rate fixing will happen according to schedule. In what follows, the earliest moment from which onwards agents are absolutely convinced of the punctual exchange-rate fixing will be termed the date-of-full-acceptance.

Figure 4 about here

Figure 4 displays the schematic representation of the exchange-rate volatility dynamics prior to the return to the gold standard as predicted by the theoretical Wilfling and Maennig (2001) model. Before the date-of-first- notice agents believe that the currently existing system of freely floating ex- change rates will hold forever so that exchange-rate volatility is high (extreme high-volatility regime). Next, we consider the time between the date-of-full- acceptance and the return to gold. During this period, all uncertainty about the punctual fixing will have been completely resolved so that exchange- rate volatility should be low and, according to the theoretical model, should converge to zero shortly before the implementation of the gold standard (extreme low-volatility regime). Finally, we consider the time between the date- of-first-notice and the date-of-full acceptance during which agents begin to incorporate the potential future exchange rate fixing into their currency valuation schemes, but—owing to relevant news—more or less frequently modify their assessments about the punctual return to the gold standard.

Depending on the changes in these assessments, this period is typically characterized by news-induced switches between high and low exchange-rate volatility regimes. Wilfling and Maennig (2001) derive analytical formulas for the conditional exchange-rate volatility during this period of uncertainty. They also prove that exchange-rate volatility during this period strictly lies between the volatility levels from the above-described high- and the low-volatility regimes what justifies the notion 'intermediate exchange-rate volatility' used in Figure 4.

Finally, it should be noted that the date-of-first-notice and the date-of- full-acceptance are both free to vary along the time axis in Figure 4 so that this framework covers a broad range of possible scenarios. For example, both dates will coincide if market participants perceive a prospective return to the gold standard for the first time and are immediately convinced that the exchange-rate fixing will start as officially scheduled. An alternative scenario involves a considerable extent of uncertainty about the return to gold that may remain until the actual institutional implementation of the gold standard. In this case, the date-of-full-acceptance would coincide with the return to gold.

However, although theoretically possible, it is not very likely that the market uncertainty characterizing the period between the date-of-first-notice and the date-of-full-acceptance lasts for a very long time in real-world situations. Moreover, since the corresponding volatility levels necessarily range between the volatility levels of the extreme regimes, we waive modeling such intermediate regimes and focus on the detection of the two extreme volatility regimes in our subsequent econometric analysis.

In order to model the two distinct volatility regimes in our exchange-rate return

series $\{R_t\}$ which we define as

$$R_t = 100 * [\ln(X_t) - \ln(X_{t-1})] \tag{1}$$

we make use of a Markov-switching-GARCH model as developed in Gray (1996b) and recently refined in Wilfling (2009) and Gelman and Wilfling (2009). The general idea behind this econometric framework is that the data- generating process (DGP) of the return R_t is affected by a latent random variable which represents the state the DGP is in on any particular date t. In our analysis we denote this latent state variable by S_t and use it to discriminate between the two distinct volatility regimes. We specify $S_t = 1$ to indicate that the DGP is in the high-volatility regime whereas $S_t = 2$ is meant to indicate that the DGP is in the low-volatility regime.

The basic element of our Markov-switching-GARCH model is the well- known probability density function of a mean-shifted t-distribution with v degrees of freedom, mean μ and variance h, $t_{v,\mu,h}$. Based on this parametric density function, our next step will consist in specifying stochastic processes for the mean and the volatility in regime i, denoted by μ_{it} and h_{it}, according to which the exchange-rate return R_t is generated conditional upon the regime indicator $S_t = i$, $i = 1, 2$. After having specified μ_{it} and h_{it} we can then represent the conditional distribution of the return as a mixture of two mean-shifted t-distributions:

$$R_t | \phi_{t-1} \sim \begin{cases} t_{\mu_1, v_1, h_1} & with\ probability\ \ \ p_{1t} \\ t_{\mu_2, v_2, h_2} & with\ probability\ (1 - p_{1t}) \end{cases}' \tag{2}$$

where ϕ_{t-1} defines the information set as of date $t-1$ and $p_{1t} \equiv \Pr\{S_t = 1/\phi_{t-1}\}$ denotes the so-called *ex-ante* probability of being in regime 1 at time t.

In modeling our regime-dependent mean equation, we consider a simple form

by assuming a first-order autoregressive process (AR(1)-process) in each regime yielding

$$u_{it} = a_{0i} + a_{1i} * R_{t-1}. \tag{3}$$

In contrast to the mean equation (3), the specification of an adequate GARCH process for the regime-specific variance h_{it} is more problematic. Without going into technical detail, we first consider an aggregate of conditional return variances from both regimes at date t:[3]

$$h_t = E[(\mu_{it} + \varepsilon_{it})^2] - \{E[\mu_{it} + \varepsilon_{it}]\}^2$$

$$= p_{1t}(\mu_{1t}^2 + h_{1t}) + (1 - p_{1t}) * (\mu_{2t}^2 + h_{2t}) - \{p_{1t} * \mu_{1t} + (1 - p_{1t}) * \mu_{2t}\}^2 \tag{4}$$

The quantity h_t now provides the basis for the specification of the regime-specific conditional variances h_{it+1}, $i = 1, 2$ in the form of a parsimonious GARCH(1,1)-structure. More explicitly, we follow the suggestion in Dueker (1997) and first parameterize the degrees of freedom of the $t_{v,\mu,h}$-distribution by $q=1/v$, so that $(1-2q)=(v-2)/v$, and then specify our regime-specific GARCH-equation as

$$h_{it} = b_{0i} + b_{1i} * (1 - 2q_i)\varepsilon_{t-1}^2 + b_{2i}h_{t-1} \tag{5}$$

with h_{t-1} as being given according to Eq. (4) and $_{t-1}$ being obtained from

$$\varepsilon_{t-1} = R_{t-1} - E[R_{t-1}|\phi_{t-2}] = R_{t-1} - [p_{1,t-1} * \mu_{1,t-1} + (1 - p_{1,t-1}) * \mu_{2,t-1}] \tag{6}$$

It is important to note here that for $i = 1, 2$ the sums $b_{1i}(1-2q_i)+b_{2i}$ of the coefficients from Eq. (5) constitute convenient measures of the regime-specific persistence of volatility shocks. The higher the value of this measure the more time it takes until a shock dies out. A regime-specific volatility shock will die out in finite time if the coefficient sum is less than 1. For the case of the coefficient sum being equal to 1 (i.e. for an integrated GARCH(1,1) process) volatility shocks have a permanent effect and the unconditional variance of the process becomes

infinitely large.

Finally, we close our Markov-switching-GARCH model by parameterizing the regime indicator S_t as a first-order Markov process with constant transition probabilities. Denoting by π_i he probability of the DGP persisting in regime i (for i = 1, 2) between the dates $t-1$ and t, we specify

$$Pr\ (S_t = 1|S_{t-1} = 1) = \pi_1 \qquad\qquad (7)$$

$$\text{Pr}\ (S_t = 2|S_{t-1} = 1) = 1 - \pi_1,$$

$$\text{Pr}\ (S_t = 1|S_{t-1} = 2) = 1 - \pi_2,$$

$$\text{Pr}\ (S_t = 2|S_{t-1} = 2) = \pi_2.$$

Now, the log-likelihood function of our Markov-switching-GARCH(1,1) model can be obtained by performing similar calculations as in Gray (1996b). The exact form of the function is presented in Wilfling (2009). The log-likelihood function contains the *ex-ante* probabilities $p_{1t} \equiv \text{Pr}\{S_t = 1/\phi_{t-1}\}$ which can be estimated via a recursive scheme. These probabilities are useful in forecasting one-step-ahead regimes based on an information set that evolves over time. In our context, the *ex-ante* probabilities p_{1t} reflect current market perceptions of the one-step-ahead volatility regime, thus representing an adequate measure of foreign exchange market volatility sentiments. Besides the *ex-ante* probabilities p_{1t} we also address the so-called *smoothed* probabilities $\text{Pr}\{S_t = 1/\phi_T\}$ which can be computed by the use of filter techniques after the model estimation has been carried out.[4] The *smoothed* probabilities are based on the full sample-information set ϕ_T and provide a tool for inferring *ex post* if and when volatility regime switches have occurred in the sample.

Table 1 about here

V

Table 1 presents the maximum-likelihood estimates of our Markov-switching GARCH model. Maximization of the log-likelihood function was performed by the 'MAXIMIZE'-routine within the software package RATS 6.1 using the BFGS-algorithm, heteroscedasticity-consistent estimates of standard errors and suitably chosen starting values for all parameters involved. In contrast to our theoretical mean equation (3) we estimated an AR(1)-process with identical, non-switching parameters across both regimes. We imposed the simplifying restriction $a_{01} = a_{02}$ and $a_{11} = a_{12}$ for two reasons, namely (1) in order to reduce the number of parameters to be estimated, and (2) to focus on the volatility features of the exchange-rate returns.

In the first step of the empirical analysis we address the statistical significance of the model parameters on the basis of the conventional t-statistics. To this end some comments on the probability distribution of the conventional t-statistic within our Markov-switching-GARCH framework are in order. It has to be noted that the exact finite-sample distribution of our t-statistics is generally unknown. However, owing to some well-known asymptotic properties of general maximum-likelihood estimators in conjunction with an appropriate limiting-distribution result, it can be concluded that under the null hypothesis of a single parameter being equal to zero, our t-statistics should converge in distribution towards a standard normal variate. This implies asymptotic critical values of 2.58, 1.96 and 1.64 for the absolute value of the t-statistic at the 1, 5, and 10%-levels,

respectively. Overall, we find that 9 out 12 parameters from our mean and GARCH equations (3) and (5) are statistically significant at the 1% level.

The GARCH parameters of regime 1, b_{01}, b_{11}, b_{21} appear much larger than their corresponding counterparts b_{02}, b_{12}, b_{22} in regime 2. In conjunction with the (modified) degree-of-freedom parameters q_1 and q_2 the regime-specific volatility persistence measures $b_{1i}(1 - 2q_i) + b_{2i}$ are given by 0.6615 in regime 1 and $8.3 \cdot 10^{-6}$ in regime 2 indicating a substantially higher degree of volatility persistence in regime 1 than in regime 2. However, both volatility persistence measures are less than 1 which suggests stationary conditional volatility processes in both regimes implying that regime-specific volatility shocks die out in finite time. The estimates of the transition probabilities π_1 and π_2 are given by 0.9776 and 0.8096 indicating a particularly high degree of regime persistence for regime 1.

Apart from parameter estimation we also performed several specification tests and diagnostic checks of the model fit. Inter alia, we tested for serial correlation of the squared standardized residuals for the lags 1, 2, 3, and 5 with the well-known Ljung-Box-Q-test finding that the null hypothesis of no autocorrelation cannot be rejected up to lag 5 at any conventional significance level. This result provides some evidence in favor of our two-regime Markov- switching GARCH specification.[5]

$$\boxed{\textit{Figure 5 about here}}$$

Next, we address the *ex-ante* and the *smoothed* probabilities $\Pr\{S_t = 1/\phi_t\}$ and $\Pr\{S_t = 1/\phi_T\}$ both of which are relevant to detecting how often and at which

dates the exchange-rate returns switched between the high-volatility and the low-volatility regimes. Figure 5 displays these regime-1 probabilities (in the upper panels) along with the conditional variance process (in the lower panel) estimated from our Markov-switching GARCH model.

Theoretically, we would expect to observe dynamics of the regime-1 probabilities (more concretely of both the *ex-ante* as well as the smoothed regime-1 probabilities) in line with the schematic representation depicted in Figure 4. Before the date-of-first notice exchange-rate volatility is high and, consequently, the regime-1 probabilities should be close to 1. Between the date- of-first notice and the date-of-full acceptance exchange-rate volatility should attain an intermediate level with regime-1 probabilities fluctuating between 1 and 0 while exchange-rate volatility should be low after the date-of-full acceptance until the actual return to the gold standard with regime-1 probabilities being close to 0.

In line with these theoretical considerations the vast majority of the regime-1 probabilities depicted in Figure 5 are indeed close to 1 at the be- ginning of the sampling period. During this period the DGP is in the high- volatility regime as indicated by the conditional variances shown in the lower panel of Figure 5. Between January 1876 and January 1878 the regime-1 probabilities exhibit more frequent downturns towards zero indicating the interim period between the two alternative exchange-rate systems during which market participants became increasingly convinced of the future switch in exchange-rate regime. Finally, in May 1878 the regime-1 probabilities start a sustained decline from one towards zero for the rest of the sampling period reflecting the switch to the low-volatility regime as suggested by the schematic representation from Figure 4.

Interestingly, we can explain some of the downturns in the regime-1 probabilities by decisive historical events. We observe, for example, an increasing number of downturns during the year 1877 which we explain as being triggered by Hayes' victory in the presidential elections in November 1876 since Hayes was well-known for his sound money attitude what might have strengthened financial market participants' beliefs in the Resumption Act. However, it was not until May 1878 that the regime-1 probabilities exhibit a more persistent decline towards zero indicating the entrance into the low- volatility regime. While before that date the Bland-Allison Act of January 1878 might have kept the DGP in the high-volatility regime 1 (although its impact on the credibility of the resumption appears questionable) we attribute the sustained switch to the low-volatility regime 2 in May 1878 to the Silver Act which did not affect the legal commitment to resume on January 1, 1879. Furthermore, we interpret the persistent change in the regime-1 probabilities after May 1878 as a substantial change in financial market participants' expectations. This interpretation is compatible with anecdotal evidence reporting that Sherman's efforts to accumulate sufficient gold reserves for resumption were considered credible.

A closer look at the conditional variances depicted in the lower panel of Figure 5 reveals that the variances stay below the value 0.025 most of the time and even below 0.01 on 794 sampling days. It is presumably this narrow range of volatility levels which makes it difficult to distinguish sharply between high- and low-volatility regimes so that our regime-1 probabilities do not appear as clear-cut as suggested by our theoretical reasoning. However, we sum up by emphasizing that our Markov-switching GARCH framework is capable of locating a date after

which market participants appeared to be convinced of the resumption. We identify this date as June 1878 after which the DGP of our Markov-switching GARCH model remains in the low- volatility regime most of the time. By contrast, we do not find that clear-cut empirical evidence around the start of the resumption process for which our model appears to switch erratically between the volatility regimes. We interpret this result as evidence for a high degree of uncertainty in U.S. financial markets after the Civil War.

VI

In this paper we analyze volatility changes in daily greenback-gold conversion rates after the U.S. Civil War with the objective of characterizing the greenback's eventual return to convertibility in 1879. To this end we allow the greenback returns to endogenously switch between high- and low-volatility regimes and model this scenario within a Markov-switching GARCH frame- work. Our methodology is able to locate the shift to low exchange-rate volatility and thus identifies the time when market participants assessed the implementation of the announced fixed exchange-rate regime fully credible.

Our contribution to America's historiography consists in the finding that the switch to convertibility announced for January 1, 1879 became credible half a year earlier in summer 1878. In the light of the intense political struggle between inflationists and bullionists after the Civil War this result is quite surprising. Regarding only qualitative evidence from historical sources, one might be inclined to conjecture that the question of convertibility had not been settled before its ultimate implementation on January 1, 1879. However, despite all

controversial discussions, our volatility analysis provides strong quantitative evidence that political leaders could credibly commit to their policy announcement.

Apart from its historical focus our volatility analysis also contributes to the general debate about the economic factors that drive the exchange rate. Significant volatility regime-switching, as observed in this study, is likely to be caused by changing expectations rather than by changing fundamentals. Consequently, we interpret our empirical findings as endorsing evidence emphasizing the substantial role of financial market expectations in exchange-rate determination.

The transition from a system of floating exchange rates to a fixed-rate system is a topic of major concern to economic historians.[6] However, the bulk of this literature focuses on theoretical models capturing specific features of the exchange-rate dynamics during this transitional period (see, *inter alia*, Flood and Garber, 1983; Froot and Obstfeld, 1991). Besides a very few exceptions scattered in the literature (e.g. Smith and Smith, 1990) our study is one of a few analyzing the return to a fixed exchange-rate regime empirically. We believe that apart from its application to the greenback resumption, our approach to analyzing switching structures in exchange-rate volatility may be successfully applied to other comparable historical episodes.

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Footnotes

[1] The data can be accessed online at http://EH.net/databases/greenback.

[2] There still is controversy on the exact day dating the end of the Civil War. For an overview treating the significant events of the Civil War see Rhodes (1999).

[3] See Gray (1996b) for a rigorous formal discussion.

[4] In this paper, we have computed all *smoothed* probabilities with a filter algorithm provided by Gray (1996a)

[5] Technical details of our specification and autocorrelation tests are available upon request.

[6] See for example Miller and Sutherland (1994) concerning the debate about sterling's return to gold after World War I.
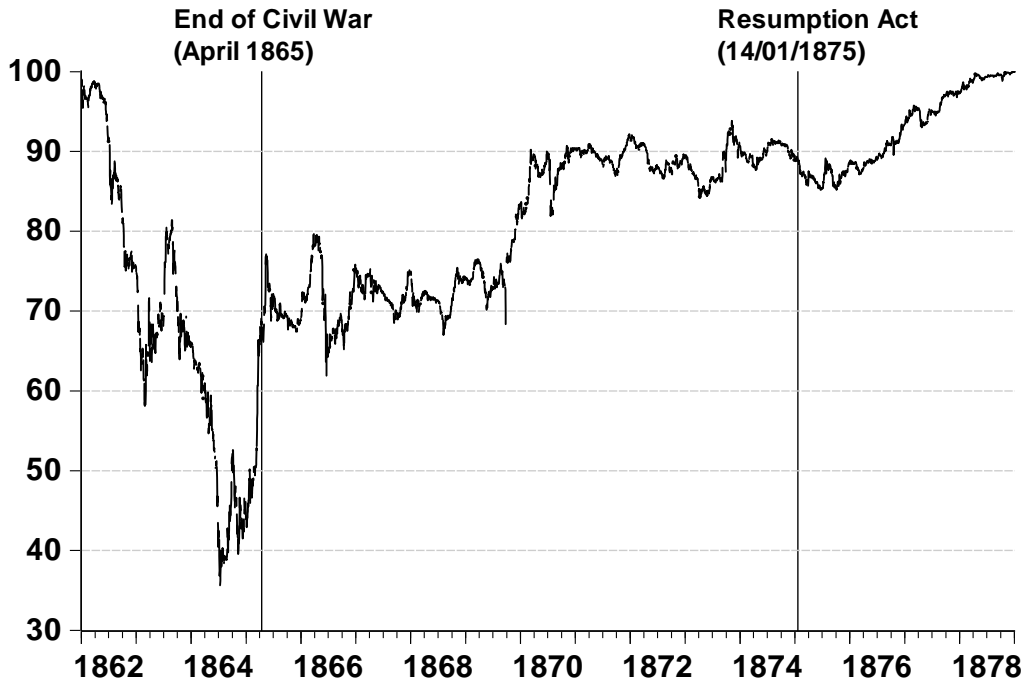
Figure 1: Golddollar/greenback exchange rate from 1862 to 1879
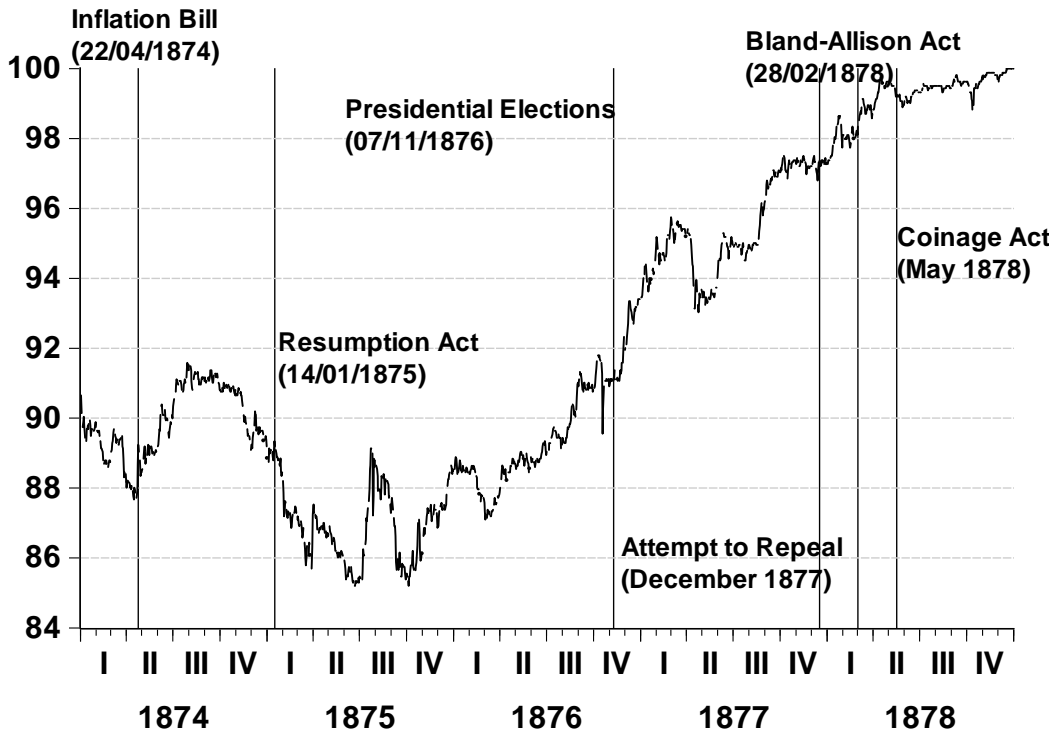
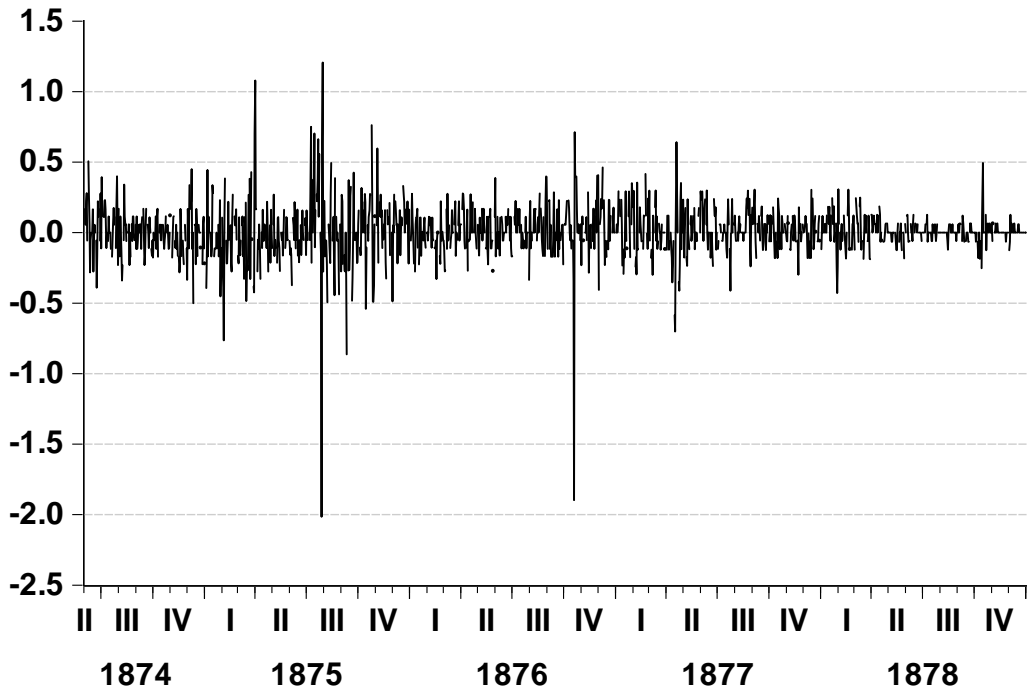Figure 2: Golddollar/greenback exchange rate from 1874 to 1879 and significant events

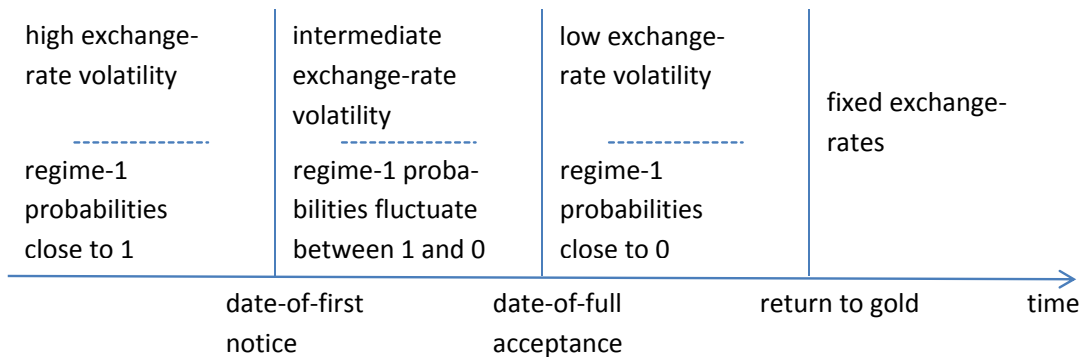Figure 3: Daily returns from June 1874 to December 1879

Figure 4: Schematic representation of exchange-rate volatility dynamics according to the Wilfling and Maennig (2001) model
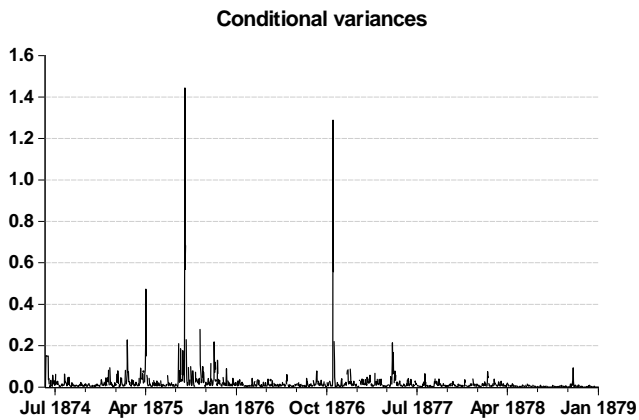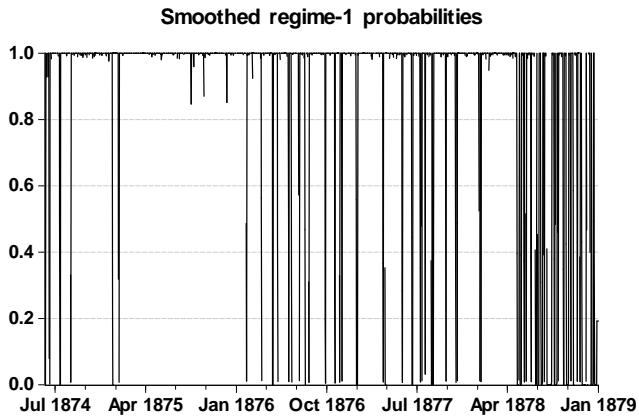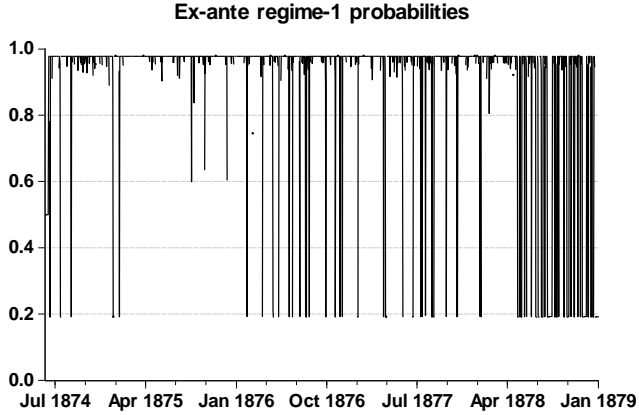
Figure 5: *Ex-ante* regime-1 probabilities, smoothed regime-1 probabilities and conditional variances of exchange-rate returns

Table 1
Estimation results for the Markov-switching-GARCH model

	Estimate	Std. error
Mean equation:		
(identical in both regimes)		
$a_{01} = a_{02}$	0.0000	0.0000
$a_{11} = a_{12}$	-0.0021***	$2.29 \cdot 10^{-11}$
Regime 1:		
b_{01}	0.0023***	$1.85 \cdot 10^{-11}$
b_{11}	0.5992***	$4.98 \cdot 10^{-10}$
b_{21}	0.3001***	$8.57 \cdot 10^{-10}$
$q_1 = 1/\nu_1$	0.1984***	$7.70 \cdot 10^{-10}$
$[\hat{b}_{11} \cdot (1 - 2\hat{q_1}) + \hat{b}_{21}]$	[0.6615]	
Regime 2:		
b_{02}	0.0000	0.0000
b_{12}	0.0081***	$7.83 \cdot 10^{-6}$
b_{22}	0.0000	0.0000
$q_2 = 1/\nu_2$	0.4996***	$3.96 \cdot 10^{-11}$
$[\hat{b}_{12} \cdot (1 - 2\hat{q_2}) + \hat{b}_{22}]$	$[8.30 \cdot 10^{-6}]$	
Transition probabilities:		
π_1	0.9776***	$1.22 \cdot 10^{-6}$
π_2	0.8096***	$1.13 \cdot 10^{-9}$

Note: Estimates for parameters from the Eqs. (2) to (7). ***, ** and * denote statistical significance at the 1, 5 and 10 % levels, respectively.