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Scott L. Fulford
Consumer Financial Protection Bureau

Felipe Schwartzman
Federal Reserve Bank of Richmond

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The Benefits of Commitment to a Currency Peg: Aggregate Lessons from the Regional Effects of the 1896 U.S. Presidential Election

Scott L. Fulford* and Felipe Schwartzman†

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Abstract

We develop a method to use the one-time cross-sectional impact of a cleanly identified shock to identify its aggregate impact through the use of a factor model. We apply this methodology to evaluate the importance of fluctuations to the commitment to a currency peg for macroeconomic outcomes during the gold standard period in the U.S. The presidential election in 1896 provides a cleanly identified positive shock to commitment to the gold standard. After the election, bank leverage increased substantially, particularly in states where gold was in greater use. Using the latent factor identified by the election, we find that full commitment to gold had the potential to reduce the volatility of real activity overall by a significant amount in the last two decades of the 19th century, as well as substantially mitigate the economic depression starting in 1893.

JEL classification: E42, E44, F33, G01

Keywords: Gold Standard; National Banks; Fixed Exchange Rate; Exchange Rate Credibility; Financial Crisis; Factor Analysis

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†Federal Reserve Bank of Richmond, Felipe.Schwartzman@rich.frb.org (804 697-8000, P.O. Box 27622, Richmond, VA 23261). The views expressed here are those of the authors and do not reflect those of the Federal Reserve Bank of Richmond or the Federal Reserve System.

1 Introduction

Exchange rate and banking crises are often intertwined, as observed around the Great Depression (Eichengreen, 1992), in the second half of the 20th century (Kaminsky and Reinhart, 1999), and in the recent instability around the European Monetary Union. A substantial theoretical literature points out that causality can run in either direction.[1] We develop a methodology to use information from the cross-sectional impact of a one-time shock to the credibility of the gold standard in the U.S.—the 1896 U.S. presidential election—to shed light on this issue. We find evidence of significant effects of uncertainty about the peg on bank behavior and broader economic activity.[2]

Our methodology deals with a challenge affecting most work that tries to leverage microeconomic data sources to understand macroeconomic phenomena: no matter how granular, a single cross-section does not allow one to distinguish the general equilibrium effects of a one-time shock from other underlying aggregate movements. Our method allows us to use a one-time, well-identified historical event to construct a time series for the driving process of interest through a comparison of cross-sectional data between periods. More formally, we use the change in cross-sectional variables around the date of the historical event to identify the loadings of a time-varying latent factor estimated using principal component methods. Once obtained, this time-series variation can then be used to identify the aggregate impact of the shock using standard methods.

In its simplest version, the methodology requires an aggregate shock that (i) is the only important factor driving cross-sectional changes within a narrow time window identified from the historical record and (ii) has an impact in the cross-section that is uncorrelated with the impact of other shocks. We also show how both of these assumptions can be relaxed with further information on specific time windows when other shocks might have been relevant.

We use the 1896 U.S. presidential election to identify shocks to the credibility of the gold standard. The 1896 U.S. presidential election provides unique insight into our question, since the central issue was whether the United States would stay on the gold standard, and the outcome

[1]See Aghion, Bacchetta, and Banerjee (2001) for a discussion of spillovers from currency crises to corporate finance and Obstfeld (1996) for how a banking crisis could lead the government to decide to withdraw from a peg.

[2]Those findings have been independently corroborated by Weiss (2017) using a distinct methodology, focusing on the impact of uncertainty surrounding the Gold Standard on corporate bonds.

remained uncertain till the end. Immediately after the election, overall banking activity, as measured by banks' leverage, increased sharply and particularly so in states where bank depositors were more likely to use gold for transactions. Both of these effects, we show, are consistent with a banking model in which banks have to compete for depositor's savings with assets denominated in other currencies.

Informally, our method identifies periods of increasing credibility of the gold standard to be ones where the pattern of changes in bank balance sheets across states matches those observed around the 1896 election. To apply our method, we provide evidence from the historical record that: (i) the election was the main aggregate shock in the last months of 1896 (Section 3), and (ii) the election's cross-sectional impact is uncorrelated with other possible shocks by comparing it with other dates when other shocks were likely to have played a larger role but the credibility of the exchange rate peg was not in question (Section 4). We also show in Section 2 how to formally use information from these alternative dates as controls in the construction of the credibility index and find that they do not affect the main findings much.

The index identified through the factor analysis tracks large swings in aggregate bank leverage before 1900. After 1900, when the Gold Standard Act removes any remaining uncertainty about the gold standard, the index is much less variable and is no longer correlated with bank leverage, suggesting that uncertainty about the monetary regime was a key driver of financial instability in the period before 1900 but not afterward. The index is furthermore closely correlated with other possible measures of credibility such as the amount of gold held by Treasury and the premium for payment with gold.

We then evaluate how important exchange rate credibility is for real activity by performing a structural VAR analysis of the interaction between the index and measures of economic activity. Using different identification approaches, we find that, under most scenarios, stabilizing credibility would have been associated with an economically significant reduction in variation in business failures in the 1880s and 1890s. Most strikingly, we find that those fluctuations appear to account for between 50 percent and 75 percent of the increase in business failures around the 1893 panic, which led to massive unemployment (Romer, 1986). At the same time, fluctuations in our index played no role after the formal adoption of the gold standard in 1900, even though it includes a significant episode of financial turbulence in the 1907 panic. It appears from our analysis that the formal adoption of the gold standard in 1900 was able to eliminate one important source of financial and real instability.

While much of the theoretical literature and historical narratives emphasize currency mismatch among financial firms (for example, see Diaz-Alejandro (1985) and Choi and Cook (2004)), the high concentration of the financial sector has forced much of that literature to focus either on cross-country data (Calvo, Izquierdo, and Mejía, 2008) or on data from nonfinancial corporations (see Galindo, Panizza, and Schiantarelli (2003) for a review). In contrast, the 1896 U.S. election presents the rare opportunity to observe the impact of a common shock to the credibility of the exchange rate regime on a cross-section of comparable financial institutions facing the same regulatory environment but serving localized clienteles with distinct financial needs. Our paper therefore contributes to a large empirical literature quantifying the importance of financial factors in propagating movements in the exchange rate in modern economies. Importantly, our paper complements that literature by highlighting the costs of imperfectly credible currency pegs that occur before a devaluation takes place.[3]

2 Event-Based Identification of Factors

We now show how one can combine historical knowledge of an important macroeconomic shock with rich cross-sectional data to identify a time-varying index corresponding to the main shock driving that event. The method builds on the principal component approach to estimation of a factor model (see, for example, Stock and Watson (2003)).

Let $X_t = \{x_{1,t}, x_{2,t}, ..., x_{N,t}\}$ be a $1 \times N$ vector of "informational" variables, i.e., variables

[3] See also Richardson and Troost (2009) and Carlson, Mitchener, and Richardson (2011) for two recent papers using historical episodes to better understand the propagation of financial crises. The period has more generally received a great deal of study both for understanding the benefits and costs of imperfect currency pegs (Grilli, 1990; Calomiris, 1992; Hallwood, MacDonald, and Marsh, 2000) and the causes and consequences of banking panics (Noyes, 1909; Sprague, 1910; Wicker, 2000). The regulations and competition among banks during the period have also made it useful for understanding the effects of financial development (Jaremski and Rousseau, 2013; Fulford, 2015).

that we believe are likely to contain meaningful information about the factor we are interested in identifying. For any given entry in this vector $x_{i,t}$, we assume that:

$$x_{i,t} = \sum_{r=1}^{R} \lambda_{i,r} F_{r,t} + \varepsilon_{i,t},\ i \in \{1,..,N\}, t \in \{1,...,T\},$$

where $R < N$, $F_{r,t}$ are time-varying factors and $\lambda_{i,r}$ are factor loadings that vary across variables but not over time. The assumption $R < N$ implies that the changes over time in the N dimensional vector $x_{i,t}$ can be well captured by a reduced number of factors R. Those factors capture aggregate shocks that affect all the informational variables, with the residuals $\varepsilon_{i,t}$ capturing idiosyncratic shocks, which are only relevant for one particular variable. Under mild conditions on the correlation structure of $\varepsilon_{i,t}$ (see, for example, Stock and Watson (2003)), one can show that for large N and T it is possible to consistently estimate the space spanned by $F_{r,t}$ using principal component analysis. Thus, a factor analytic approach allows one to identify the part of the variation in $x_{i,t}$ that can be attributed to aggregate shocks.

Without further assumptions, it is, however, impossible to uniquely estimate the values of individual factors $F_{r,t}$ and factor loadings $\lambda_{i,r}$.[4] We now show how one can impose additional assumptions derived from the historical record to achieve that identification. Given the time-series structure of the informational variables, we allow the factors to follow a dynamic structure as in Forni et al. (2000), so that:

$$F_{r,t} = \sum_{r=1}^{R} \sum_{k=1}^{K} b_{r,k} F_{r,t-k} + \nu_{r,t},\ r \in \{1,..,R\}, t \in \{1,...,T\}.$$

where $\nu_{r,t}$ are innovations to the dynamic factor process. Without loss of generality, let $F_{1,t}$ denote the latent factor of interest. The following two assumptions allow for identification:

Assumption 1. There is some t_t for which $\nu_{1,t_1} \neq 0$ and $\nu_{r,t_1} = 0$ for $r \neq 1$.

Assumption 2. $cov(\lambda_{i,1}, \lambda_{i,r}) = 0$ for all $r \neq 1$.

[4] In matrix form, the model can be written as $X_t = \Lambda F_t + \varepsilon_t$, with $F_t = \{F_{1,t}, F_{2,t}, ..., F_{R,t}\}$ and Λ a $N \times R$ matrix with entries $\lambda_{i,r}$. It follows that for any invertible $R \times R$ matrix H, the model can be alternatively rewritten as $X_t = \tilde{\Lambda}\tilde{F}_t$ with $\tilde{\Lambda} \equiv \Lambda H$ and $\tilde{F}_t \equiv H^{-1} F_t$. See Bai and Ng (2013) for a discussion of asymptotics for identified latent factors.

Assumption 1 states that an innovation to the latent factor of interest is the only aggregate shock in the period identified by the narrative, and Assumption 2 states that the cross-sectional impact of other factors is orthogonal to that of the identified factor. Given Assumptions 1 and 2, the following proposition holds:

Proposition 1. *Suppose Assumptions 1 and 2 hold and that the sample estimates correspond to population values. Let* $\bar{x}_{i,t} \equiv \sum_{r=1}^{R} \lambda_{i,r} F_{r,t}$ *be the part of variable* $x_{i,t}$ *explained by the common factors and* $\bar{\nu}_{i,t} \equiv \sum_{r=1}^{R} \lambda_{i,r} \nu_t$ *be the part of variable* $x_{i,t}$ *explained by innovations to* $F_{r,t}$*. Then* $F_{1,t} = \frac{cov\left(\bar{x}_{i,t}, \bar{\nu}_{i,t_1}\right)}{var\left(\bar{\nu}_{i,t_1}\right)} \nu_{1,t^*}$.

The proposition describes how one can use principal components to infer $F_{1,t}$ up to a scaling constant. The identified factor is proportional to the regression coefficient of the systematic component of the informational variables at time t ($\bar{x}_{i,t}$) on the innovation to those components in the reference period t_1 ($\bar{\nu}_{i,t_1}$).

We now show that we can relax Assumptions 1 and 2 if we can find dates in which other shocks played an important role, but shocks to $F_{1,t}$ were unlikely to have been important.

Formally, suppose the following assumptions hold for K dates indexed $t_k, \ k \in \{1, ..., K\}$:

Assumption 1') $\nu_{r,t_k} = 0$ for $r > K$ and $k \in \{1, ..., K\}$

Assumption 2') $cov\left(\lambda_{i,r}, \lambda_{i,r'}\right) = 0$ if $r \leq K$ and $r' > K$

Assumption 3) $\nu_{1,t_1} > 0$ and $\nu_{1,t_k} = 0$ for $k > 1$

Assumption 4) The $K \times K$ matrix with element ν_{r,t_k} in row r, column k is invertible.

Assumptions 1' and 2' are generalizations of Assumptions 1 and 2. They state that we can find a set of K dates in which only innovations to the first K latent factors matter (Assumption 1'), and that the loadings on other factors do not correlate with those K factors (Assumption 2'). Assumption 3 states that the innovation to $F_{1,t}$, our factor of interest, is only relevant in one of the K dates (denoted t_1 without loss of generality). For example, in our application this assumption will hold if the gold standard was in question in the 1896 election, but we can identify other dates, such as any date after the passage of the Gold Standard Act in 1900, when it was not. Assumption 4 requires that the dates selected as controls include independent information about the reaction of the factors to shocks.

Given those assumptions, the following proposition holds:

Proposition 2. *Suppose Assumptions 1', 2', 3, and 4 hold and that the sample estimates correspond to population values. Let* $\bar{x}_{i,t} \equiv \sum_{r=1}^{R} \lambda_{i,r} F_{r,t}$ *be the part of variable* $x_{i,t}$ *explained by the common factors, and* $\bar{\nu}_{i,t} \equiv \sum_{r=1}^{R} \lambda_{i,r} \nu_t$ *be the part of variable* $x_{i,t}$ *explained by innovations to* $F_{r,t}$*. Also, let* $\bar{x}_t$ *be the* $N \times 1$ *vector stacking all values of* $\bar{x}_{i,t}$ *for a given time t, and let* $\bar{\nu}^* = [\bar{\nu}_{t_1}, ..., \bar{\nu}_{t_k}]$*. Let* $\{\alpha_{1,t}, \alpha_{2,t}, ..., \alpha_{K,t}\}$ *denote the OLS regression coefficients of* $\bar{x}_t$ *on* $\bar{\nu}^*$*. Then* $\alpha_{1,t} = \frac{F_{1,t}}{\nu_{1,t_1}}$*.*

It follows that, under Assumptions 1', 2', 3, and 4, one can obtain a measure of the factor of interest by regressing the systematic component of the informational variables $\bar{x}_{i,t}$ on the innovation to those components in the reference period t^* and on the innovations in other "control" dates.

2.1 Comparison with other methods

There is a tradition in macroeconomics of using crucial experiments drawn from historical narratives to shed light on macroeconomic mechanisms. Since Romer and Romer (1989), such narrative approach has been combined with econometric techniques in order to generate formal inferences. Two recent examples are proxy VARs (Mertens and Ravn (2013)) and narrative sign restrictions (Antolín-Díaz and Rubio-Ramírez, 2018).

The main advantage of our approach is the use of panel data in combination with factor analysis to separate out aggregate shocks from idiosyncratic disturbances. In comparison, while both proxy VARs and narrative sign restrictions identify shocks in VARs, they cannot separate idiosyncratic disturbances from aggregate shocks in any given instance. For that reason, they require the identification of multiple well-defined historical episodes (in proxy VARs) or the imposition of restrictions on the impact of the shock on aggregate variables in some particular instances (narrative sign restrictions). In contrast, the use of factor analysis on a panel with a large number of variables can be applied using a single well-identified episode while remaining agnostic about the aggregate impact of the shock.

The key limitation of the method laid out here is that it requires the availability of panel data and requires the assumptions laid out above to be satisfied. Sections 3 and 4 provide further evidence in favor of the assumptions for our application.

3 The 1896 Election as a Natural Experiment

The United States was technically on a bimetallic standard until 1900. However, the Coinage Act of 1873 had not made any provision for minting silver. As a result, *de facto,* only gold was in widespread circulation (Friedman and Schwartz, 1963, pp. 114-15). A new political movement, "free silver," emerged to try to bring silver back into circulation. This movement was most successful with the Sherman Silver Purchase Act of 1890, which committed the Treasury to buying large quantities of silver (Friedman and Schwartz, 1963, pp. 132-133). There was a widespread banking panic associated with capital flights away from the United States in 1893 and a subsequent economic recession. Friedman and Schwartz (1963, pp. 133) and Sprague (1910, p. 179) link the panic to the strain put on Treasury gold holdings by the Sherman Silver Purchase Act. While the Act was repealed in 1893, silver agitation continued, reaching its height in the 1896 presidential election. The selection of William Jennings Bryan as the Democratic and Populist Party candidate for the presidential election of 1896 marked the height of the divisions over the silver issue. Bryan's famous "cross of gold" speech at the Democratic National Convention established the importance of the gold standard for the election.

Bryan lost the election, and, while he would run again in 1900, after 1896 the support for silver was substantially weaker. The increase in the world supply of gold from new discoveries led to an increase in the monetary supply in the United States starting in 1897, substantially reducing the economic reasons for silver agitation (Friedman and Schwartz, 1963, p. 137).[5]

The Gold Standard Act in March of 1900 officially set the United States on a pure gold standard. The act was also significant because it required the federal government to issue bonds in order to replenish its gold reserves in case of necessity, thus eliminating the political uncertainty associated with the need to obtain congressional authorization for bond issuances, which had played an impor-

[5]For evidence linking silver purchases to political unrest in a different context, see Braggion, Manconi, and Zhu (2018).

tant role in previous years (Noyes, 1909, pp. 255–256).[6] The subsequent reelection of McKinley that November by a wide margin was viewed as an endorsement of the gold standard (Hepburn, 1903, p. 405), although silver featured much less prominently than it had in the campaign of 1896.

We now argue that the 1896 election provided a clear break in the likelihood of a dollar devaluation relative to gold, that the outcome was uncertain, and that this was the major change in the economic environment around that period, so that it can be used as a natural experiment to understand the effect of exchange rate uncertainty on bank balance sheets.

3.1 The Election as a Shock to the Perceived Probability of Devaluation

Bryan's platform proposed a bimetallic standard in which the U.S. would simultaneously guarantee parity between the dollar gold and silver. The relative parities would be set so that an ounce of gold and an ounce of silver would trade at a rate of 16 to 1. This would represent a significant relative gain for silver when compared to the approximately 32 to 1 rate prevalent at the time (see Appendix Figure A-1). In particular, Bryan was committed to buying substantial quantities of silver to raise its price (Bryan, 1909, p. 274).

The evidence suggests that such a plan was unworkable and would have led eventually to a devaluation. Meissner (2015) casts doubt on whether the U.S. would be able to unilaterally adopt such a system. Furthermore it seemed likely to many that a change in the currency standard would involve switching the payments of government debts to silver. This was most evident in April 1893 when Treasury Secretary Carlisle suggested that, due to diminishing gold reserves, it might be necessary to redeem Treasury notes in silver rather than gold, prompting an immediate sell-off in the stock market (Wicker, 2000, p. 58). The market settled somewhat only after President Cleveland issued an emergency statement that notes would be paid in gold.

The historical evidence points to Bryan's electoral loss as causing a marked shift in expectations about the commitment of the U.S. government to the gold standard. Who would win in 1896 was in doubt all the way to the end.[7] The uncertainty about the election and concerns about what

[6]The Gold Standard Act also reduced the minimum capital requirement for national banks from $50,000 to $25,000. Gou (2016) analyzes this change and finds that while new banks did open, their leverage was similar to existing banks.

[7]For example, in an article in *The Cincinnati Enquirer*, Oct. 31, reprinted in *The New York Times,* Nov. 2, 1896:

a Bryan win would do to exchange rates is evident in costly preparations against a Bryan win. We provide contemporary evidence of these costly preparations in Appendix A and show that at least some observers thought the election settled the "money question." The narrative obtained by contemporary accounts reflects broader trends presented in the top left panel of Figure 3 (we discuss the rest of the figure later). We chart the mentions of "free coinage" in the *New York Times* as well as the dates Weiss (2017) identifies as important pro-silver or pro-gold shocks. Because free coinage of silver was not the policy at the time, how often it is discussed gives a sense of how much alternate exchange rate policy was under discussion and so is a measure, albeit imperfect, of exchange rate uncertainty. Most of the activity in the number of mentions occurred between 1890 and 1896, with the largest spike right around the election. Some residual mentions remain up to 1900, at which point the number of mentions returns to low, pre-1890 values.

3.2 The Election was the Major Macroeconomic Event in the Relevant Time Window

The banking data we use are available at five different call dates every year. For our purposes, it is important to establish that no other independent macroeconomic shocks were as important during the period from the last call date before the election (Oct. 6) to the first call date after (Dec. 17).

A first concern is whether results might be contaminated by financial disturbances occurring in October 1896. Compared to other disturbances in the period, the October 1896 one appears to have been relatively minor (see Calomiris and Gorton (1991, p. 114), Wicker (2000, p. xii), and Jalil (2015)) Most importantly, narratives at the time point to the election as the main reason behind the increasing stringency for banks (Noyes, 1909), so it cannot be read as an independent macroeconomic shock.

A second concern is that the election occurred close to large increases in worldwide gold production. While gold increases in 1897 would in fact be substantial, especially from Klondike, Alaska, there is no clear evidence that those would have been clearly anticipated in the last months of 1896. The first major gold shipments from Klondike and the surrounding areas arrived in July

"The result of the election on Tuesday next is most uncertain. . . . . The Enquirer believes now that Mr. Bryan has the better chance of being elected."

16, 1897, which is the generally accepted date when the world outside of Alaska learned of the rich deposits there (Wharton, 1972, p. 86). While the first public mention of a new find on the "Cloldyke" appeared in October 1896 in the *San Francisco Chronicle*, it was important only in retrospect. That announcement would hardly have stood out as particularly important at the time. It had been well-known that there was gold in Alaska for a number of years, with the first rich strike in 1880 (Wharton, 1972, p. 3).

The small relative importance of whatever news about gold production seeped in during the last months of 1896 is apparent in the international price of gold in terms of silver (shown in Appendix Figure A-1). While the relative price did increase between October and December 1896, this growth was well within the bounds of normal fluctuations and was small relative to the increase observed over the course of 1897.

There are two additional shocks that are harder to rule out. We describe these shocks here and provide evidence that they do not invalidate our identification strategy in the next sections. One is a commodity price shock. As pointed out by Noyes (1909), news of crop failures in India arrived in October of 1896 leading to an an increase in the price of wheat per bushel in Chicago. Noyes (1909) credits this agricultural shock with handing victory to McKinley.

A second shock is to expected tariffs, because trade policy was an additional important factor distinguishing the two parties, even if it did not play as prominent a role in the election campaign. It is clear from the party platforms that gold was the most important factor in the campaign, but the two parties had different policies on tariffs and the election of Bryan would have changed tariff and other policies as well. The policy differences between McKinley and Bryan mean that there was more than one source of policy uncertainty resolved in the 1896 election, even if gold was the most important one.

4 Bank Balance Sheets around the 1896 Election

In what follows, we describe some key facts about the behavior of the balance sheets of national banks around the 1896 election, as well as a model that links the probability of devaluation to bank balance sheets. National banks were created by the National Banking Act of 1863. They differed from state banks in that they received their charter from the federal government and were subject to uniform regulatory constraints.[8] We focus on the balance sheets of national banks for several reasons. The first is that these banks were the largest financial institutions at the time, but because they could not branch, they were affected by local conditions. Moreover, these banks were important for growth and trade by providing working capital to merchants and producers (Fulford, 2015). They are thus a natural pathway for understanding how exchange rate changes affect the financial system. Finally, because of their role in the monetary system, these banks were carefully regulated and monitored, so we have frequent observations of their balance sheets disaggregated at the state level. Few other sources of data during the period have these characteristics. In Appendix Figures A-2 and A-3, we show that readily available state bank data behave similarly to the national bank data in important ways.

4.1 A Model of Exchange Rates and Bank Balance Sheets

To motivate using the differential impact of a shock to devaluation expectations on banks in different states as a means to gauge fluctuations in credibility, we now lay out a stylized model economy in which variations in the expected exchange rate between dollars and gold affect bank balance sheets. The model broadly follows Diamond and Dybvig (1983) with two key modifications: First, we allow for two types of "liquidity" shocks, with some depositors requiring gold as a means of payment and others requiring dollar notes. This distinction stems from the different denominations of gold or silver coins; from imported goods only being payable in gold; from the requirement that customer duties to the US Treasury be paid in gold; or from a generally greater acceptability of gold coin payment in gold producing areas. Second, within each state, prospective depositors differ in the likelihood that they demand each type of payment means. Consistent with our focus on bank balance sheet fluctuations outside of banking panics, we will only describe "no run" equilibria.

There are three periods $t \in \{0, 1, 2\}$ and N locations or states (indexed $n \in \{1, ..., N\}$).

[8] See also Champ (2007b) for a discussion of bank balance sheet data from the OCC and Champ (2007a) for a detailed discussion of the legal and institutional background of the era.

Households in state n start out period 0 endowed with x_n units of a perishable goods. Consumption takes place in periods 1 and 2, but preferences for consumption in either period is stochastic and only become known at $t = 1$. Specifically, household utility is given ex-post by:

$$u(c_1^m, c_1^g, c_2) = \theta \left(\rho c_1^g + (1 - \rho) c_1^m \right) + (1 - \theta) c_2,$$

where $\theta \in \{0, 1\}$ and $\rho \in \{0, 1\}$ denote, respectively, whether households have a preference for early (c_1^m, c_1^g) or late (c_2) consumption and, given preference for early consumption, whether they have a preference for goods that are payable in gold (c_1^g) or dollar notes (c_1^m). The probability of preference for early consumption $(\theta = 1)$ is δ for all households in all states. The probability of preference for goods payable in gold $(\rho = 1)$ is household specific and, for household i in state n, is equal to $\xi_n(i)$. We assume that the distribution of $\xi_n(i)$ within each state is a truncated normal, with state-specific mean μ_n, variance σ^2, and truncation points at 0 and 1.

In period 0, households can choose between acquiring gold (which we interpret broadly to include gold certificates and bonds with the gold clause), dollar notes (including greenbacks, but also all nominal liabilities of the federal government apart from gold certificates, as well as all national bank notes) or bank deposits. In period 1, households cannot exchange gold for bank notes, but they can request that banks deliver to them either type of currency in proportion to their deposits. Finally, in period 2, households receive income from assets that they still have on hand.

Devaluation occurs through variation in the period 2 yield of dollar notes. Specifically, each unit of dollar notes acquired in period 0 yields qR^m units of period 2 goods, where $q \in \{q^{devaluation}, 1\}$ is a random variable and $q^{devaluation} < 1$. Like the liquidity shocks, the devaluation state becomes known in $t = 1$, after households have made their portfolio decisions. The devaluation does not affect the yield on gold assets, which is constant and normalized to 1. We assume that there is a fringe of deep-pocketed patient investors (i.e., with no period 1 liquidity needs) who can invest in either asset in period 0, pinning down R^m to satisfy the uncovered interest parity condition $E[q]R^m = 1$.

Deposit contracts provide liquidity insurance to households by allowing them to withdraw gold or dollar notes as they choose in $t = 1$ by an amount equal to the face value of deposits D. Deposit contracts are quoted in nominal terms, so that in the event of a devaluation, dollar note withdrawals are worth less in real terms. For the part of deposits that households do not withdraw, banks in state n pay a rate of return R_n^d in period 2. Even though they provide insurance against currency demand shocks, deposits are not necessarily the best investment for all households because they pay a transaction cost τ in the last period per unit deposited in the bank. This cost can be viewed as capturing logistical costs associated with writing checks, delays in payments made by the banks, etc. We denote return on deposits net of the transaction cost by $\tilde{R}_n^d \equiv R_n^d - \frac{\tau}{1-\delta}$. Given that households have linear preferences, their optimal portfolio choices can be expressed in terms of threshold rules for their probability of demanding gold $\xi_n(i)$. Specifically, portfolio choices are summarized in the following proposition (see proof in the online appendix):

Proposition 3. *Assume* $1 - \frac{E[q]}{1+E[q]} \frac{\delta}{1-\delta} < \tilde{R}_n^d < 1$. *Let* $M_n^H(i)$, $G_n^H(i)$, *and* $D_n(i)$ *denote, respectively, the holdings of dollar assets, gold-denominated assets, and deposits by household* i *in state* n. *Then*

$$M_n(i) = x_n,\ G_n(i) = D_n(i) = 0 \text{ if } \xi(i) < \xi_n^m$$

$$G_n(i) = x_n,\ M_n(i) = D_n(i) = 0 \text{ if } \xi(i) > \xi_n^g$$

$$D_n(i) = x_n,\ M_n(i) = G_n(i) = 0 \text{ if } \xi(i) \in [\xi_n^m, \xi_n^g]$$

where

$$\xi_n^g = 1 - \frac{1-\delta}{\delta} \frac{1-\tilde{R}_n^d}{E[q]} \qquad \text{and} \qquad \xi_n^m = \frac{1-\delta}{\delta}\left(1 - \tilde{R}_n^d\right).$$

The condition $1 - \frac{E[q]}{1+E[q]} \frac{\delta}{1-\delta} < \tilde{R}_n^d < 1$ ensures that the rate of return on deposits is high enough that some households will choose to make deposits but not so high that all households will make that choice.

Proposition 3 is intuitive: a household with a low value of ξ knows that its liquidity needs will be most likely met by holding dollar-denominated assets, so it will choose to hold dollar notes directly rather than pay the transaction cost for holding deposits. Conversely, a household with a high value of ξ expects its liquidity needs to be most likely met by holding gold-denominated assets and will choose to hold those rather than pay the transaction cost for deposits. Households with intermediate values for ξ choose to store their wealth in banks. Thresholds widen as the rate of return on deposits increase: a higher $\tilde{R}^d$ implies a higher ξ_n^g and a lower ξ_n^m, increasing the number of depositors.

Crucially, for given $\tilde{R}^d$, an increase in devaluation probability decreases ξ_n^g, the threshold between deposits and gold, as dollar withdrawals from the bank become less valuable and more households decide that they would rather hold gold than dollars. In contrast, changes in the devaluation probability *does not* affect ξ_n^m, since those affect equally the value of dollar notes held directly and of dollar notes that can be withdrawn from the bank. This difference along the two margins is important, since it is what explains the cross-sectional differences in reactions between states in which gold is in high demand and in states where gold is in low demand.

Banks distinguish themselves from households in two main ways. First, they have access to a commitment technology that allows them to issue liabilities in the form of deposits. Second, they have a monitoring technology that allows them to hold high-yielding but illiquid loans. The rate of return on those loans is pinned down exogenously at $\bar{R} > 1$, and they are illiquid in that they cannot be transacted in $t = 1$. Rather, banks have to purchase them in period 0 and only receive the proceeds in period 2. Because banks commit to paying out gold or dollar notes as needed to households who choose to withdraw their deposits on $t = 1$, they have to hold liquid reserves. Their ability to diversify liquidity risk across depositors implies that they can use a fractional reserve system, where for each unit of deposit that they raise they hold $\delta(1 - \bar{\xi}_n)$ units of cash and $\delta\bar{\xi}_n$ units of gold, where $\bar{\xi}_n$ is the average value of $\xi(i)$ among depositors in state n. Banks can invest the remaining fraction $1 - \delta$ of deposits in loans. Since $\bar{R} > 1$, banks choose to invest as much as they can on loans while keeping enough reserves to satisfy the liquidity needs of their depositors. We assume that banks behave competitively, so that they make zero profits in equilibrium. If banks issue a positive amount of deposits, it has to be the case that $R_n^d = \bar{R}$. Bringing together the results in Proposition 3 with the bank choices yields the comparative static results summarized in the following proposition (see proof in the online appendix):

Proposition 4. *Assume* $\max\left\{1 - \frac{E[q]}{1+E[q]}\frac{\delta}{1-\delta} + \frac{\tau}{1-\delta}, 1\right\} < \bar{R} < 1 + \frac{\tau}{1-\delta}$. *Then*

1. *Loans increase with deposits* $\frac{\partial L_n}{\partial D_n} > 0$.

2. *Deposits in all states increase with the rate of return on loans* $\bar{R}$ *and with the expected value of dollar relative to gold* $E[q]$: $\frac{\partial D_n}{\partial \bar{R}} > 0$ *and* $\frac{\partial D_n}{\partial E[q]} > 0$.

3. *If* $\mu_n \in [\xi_n^m, \xi_n^g]$, *then deposits are more sensitive to the exchange rate in states where banks hold proportionately more gold reserves:* $\frac{\partial^2 D_n}{\partial E[q] \partial \bar{\xi}_n} > 0$.

4. *The relationship between the sensitivity of deposits to the rate of return on loans* $\frac{\partial D_n}{\partial \bar{R}}$, *and* $\bar{\xi}_n$ *is ambiguous.*

Part 1 of Proposition 4 follows from the fact that only banks can give loans to firms but are constrained in their ability to attract deposits. Part 2 follows directly from Proposition 3 and $R_n^d = \bar{R}$ and has been discussed above. Part 3 follows from the fact that, given the restrictions on the distribution of $\xi_n(i)$, states where households on average are more likely to demand more gold for payments are also states in which banks hold more gold in reserves to satisfy those needs and in which the density of households at the indifference threshold between holding deposits and holding gold is higher. Part 4 follows from the observation that higher returns on loans attract depositors along both margins. In what follows, we argue that, given Proposition 4, bank balance sheet data from the period are consistent with there being a sharp change in the expected value of the dollar relative to gold around the 1896 election.

4.2 Bank Balance Sheet Data

Our main data consist of the balance sheets of national banks between 1880 and 1910 as reported in five call dates distributed over the year, consolidated at the state level. The National Banking Act required national banks to report several balance sheet items to the Office of the Comptroller of the Currency (OCC) at five annual call dates, and the OCC would in turn publish the data in annual reports to Congress. Weber (2000) provides these data in electronic form. We have independently checked the call reports during much of the period and the Weber (2000) data match the call reports. Figure 1 shows how the components of national bank balance sheets evolved during the period.

We construct our main variables of interest from the balance sheet items for individual states. We focus particularly on the behavior of leverage as measured by the ratio of debt to assets. Leverage provides a useful way of normalizing changes in bank activity across different states with very different sized banking sectors or ones that are growing at different secular trends. The present emphasis on leverage is in contrast to much of the previous work on the period, which has emphasized bank suspensions as an indicator of bank distress (Wicker, 2000; Carlson, 2005).[9] Throughout, we exclude from our definition of assets and liabilities the bonds required to secure circulation of national bank notes. By doing so, we remove the direct note circulation function of these banks and so only focus on their modern banking functions for comparability.[10]

4.3 Balance Sheets around the Election

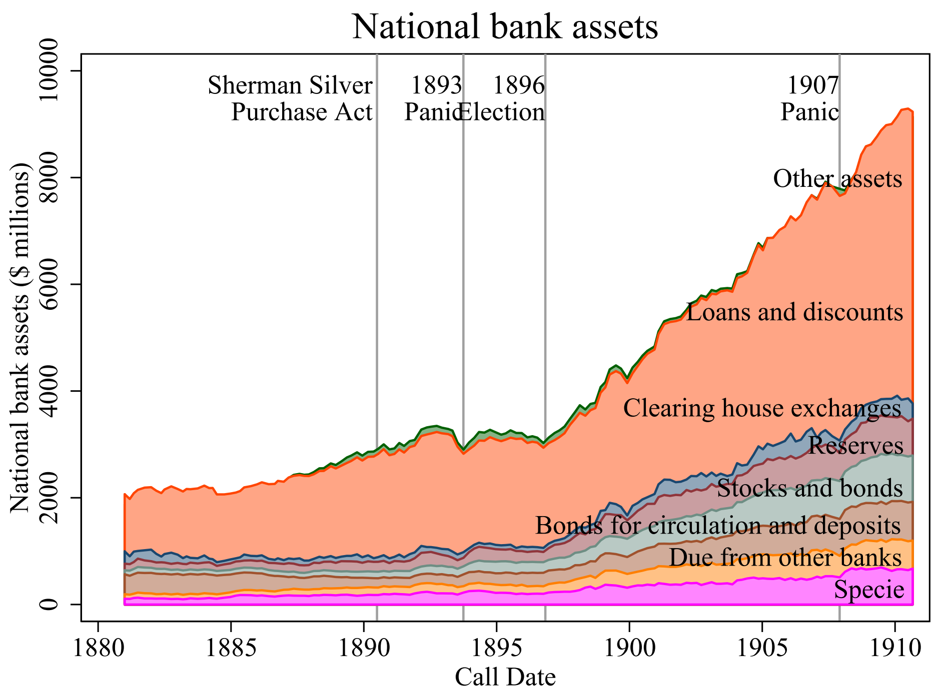
Figure 1 shows that immediately following the election, aggregate national bank assets and liabilities increased sharply and continued to increase. The increase is almost entirely from an increase in individual deposits on the liability side and loans and discounts on the asset side. Because equity—the sum of capital stock and "other equity"—hardly changed, immediately following the 1896 election the leverage ratio (debt/assets) of national banks increased substantially and continued to increase over the next three years. Leverage moved from an average of 67 percent before the election to 80 percent after (or an increase of debt-to-equity from 2 before the election to 4 after). Moreover, as Figure 1 shows, the specie held by banks was also relatively constant. Appendix Figure A-4 shows leverage as well as the ratio of specie-to-assets over the entire time period.

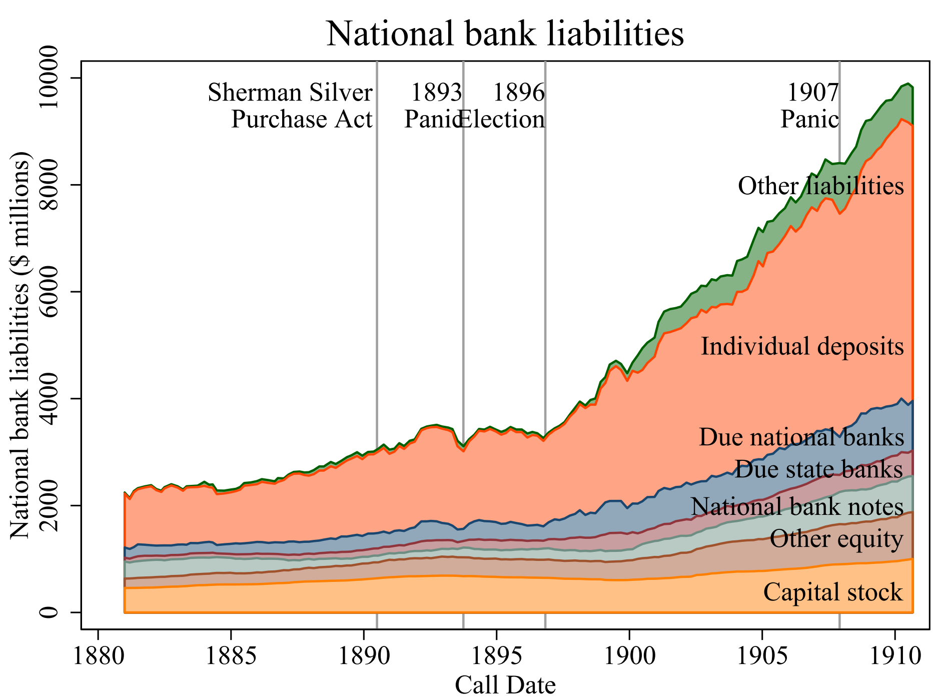
The model implies that the change in leverage around the election ought to have been particularly pronounced in states where gold was widely held. While we do not have any measure of

[9]The use of leverage data is also in line with Gertler and Kiyotaki (2010). One further advantage of bank leverage as an indicator of bank distress is that suspensions are only observed in extreme negative states.

[10]Banks could issue up to 90 percent of the bonds for circulation, raised in 1900 to 100 percent. Because note issues changed only very slowly and our focus is on short-term changes, none of the conclusions are sensitive to excluding bonds for circulation.

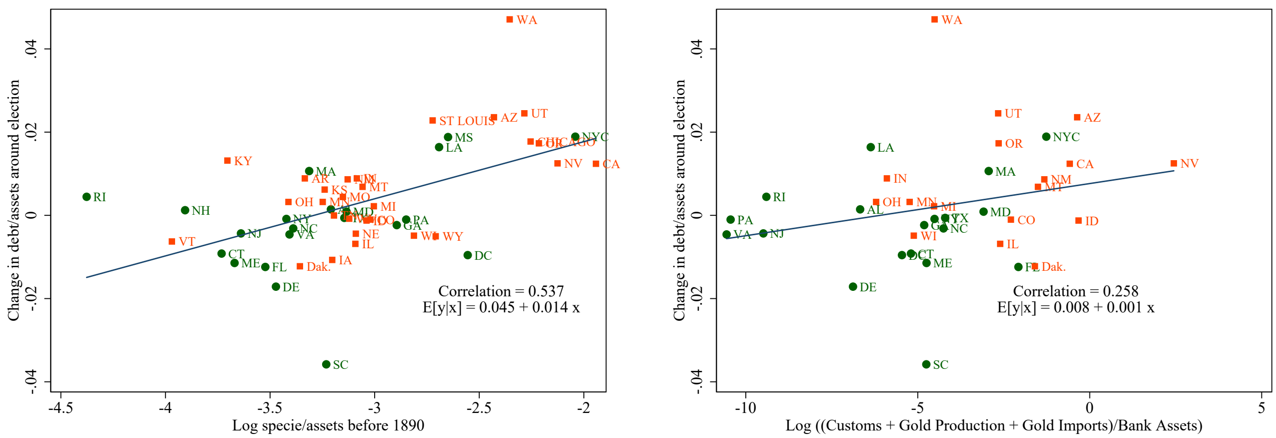
Figure 1: Aggregate national bank assets and liabilities





Source: Weber (2000) from the Annual Reports of the Comptroller of the Currency and author calculations.

Figure 2: Gold use and changes in bank deposits around the 1896 election



Notes: This figure shows the relationship between measures of how important gold was in the local economy and changes in the debt-asset ratio before and after the 1896 election. National bank assets are from Weber (2000) and the Annual Reports of the Comptroller of the Currency. Gold imports and production are from the Statistical Abstract of the United States 1895. Customs receipts are from the Annual Report of the Secretary of the Treasury 1890. Central reserve cities are included independently from their states in the left-hand panel.

direct holding of gold-denominated assets by all individuals, we do have some measures of gold held by banks.[11] The left-hand panel of Figure 2 shows that states whose banks held more specie as a share of assets before 1890 had substantially larger increases in the debt-to-assets ratio around the election. We focus on the average holding of specie before 1890 to avoid direct endogeneity with bank choices in 1896. Due to their special status as central reserve cities where other national banks kept their reserves, we also show New York City, Chicago, and St. Louis separately. The correlation between changes in leverage and gold holding is particularly large around the election, at 0.537. One could worry that this correlation reflects state-specific trends or persistent reactions to prior shocks (most notably the 1893 recession). In Appendix Figure A-5, we show that the correlation was close to zero for most of the other call dates in 1896. Furthermore, it is apparent that the correlation is also not an end of the year effect, since the correlation is 0.026 in the last call date of 1895.

States exhibiting both high specie ratios and high reaction to the 1896 election include locations as disparate in population, urbanization, and economic structure as New York City and California,

[11] The data do not discriminate between gold and other metals. However, in 1891, out of $183 million held by banks in specie, $151 million were held in gold or gold certificates issued either by the Treasury or by clearinghouses.

Table 1: Change in Bank Leverage Around the 1896 Election

	Dep. var: Change in bank leverage in 1896 election			
	(1)	(2)	(3)	(4)
Independent variable:	OLS	OLS	TSLS	OLS
Specie/Assets (pre 1890)	0.0137***		0.0105***	0.0116**
	(0.00348)		(0.00191)	(0.00506)
Gold Use Index		0.000941***		
		(0.000250)		
Additional controls				Yes
N	50	52	50	48
R-squared	0.289	0.012	0.273	0.323

Notes: This table shows how the change in bank leverage (debt/assets) across states around the 1896 election is related to other important variables. The TSLS shows the two stage least squares estimate using the gold use index as an instrument for the pre-1890 specie-assets ratio. The columns with additional controls include the following variables for 1896 and the comparison year (full definitions are in Appendix C): the state bank fraction of all bank assets in each state, the fraction of national bank assets held in reserves, the (log) population, the fraction of the population that is urban (population greater than 25,000), and the fraction of agricultural production in total production, and being on the eastern seaboard. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

lending credence to the notion that the importance of gold rather than other factors was behind the heterogeneous impact of the election.

The specie-to-assets ratio from 1890 might still suffer from an endogeneity problem as a measure of the availability of gold in different states because it stems, at least in part, from a choice made by banks. As an alternative, we combine measures of determinants of demand for gold in different states, namely gold production, gold imports, and customs duties (see Appendix C for sources). Each of these components represents a flow associated with an economic agent acquiring additional gold or making a payment in gold locally, but they do not exhaust the uses for gold. Customs receipts add to the circulation of gold in the state since the federal government required that they be paid in gold or gold certificates. Four states had no recorded gold production, customs, or imports. These states had lower specie holdings in general in 1890.[12] With this measure in hand, we verify in the right-hand panel in Figure 2 that the change in the debt-to-assets ratio around the the 1896 election is also positively associated with this measure of the local use of gold. Table 1 presents the results described above more formally. Column 1 is an OLS regression of the change

[12]The four states are Arkansas, Kansas, West Virginia, and Wyoming. They have an average specie/assets ratio on the 17 May 1890 call date of 4.15 percent, well below the average of 4.87 percent.

in leverage in each state around the 1896 election against the average specie/asset ratio before 1890. The coefficient of 0.0137 implies that a one standard deviation increase in the log specie/asset ratio of 0.517 (see Figure 2 for the scatter plot) produces a 0.71 percentage point increase in leverage or a little over a 1 percent increase in leverage, which averaged 67 percent before the election. Column 2 shows the OLS regression with our gold use measure as an explanatory variable. We can alternatively view the gold availability measure as an instrument to control for the endogenous choice of specie-assets holding by banks. The exclusion restriction is that determinants of gold use are orthogonal to other determinants of gold holdings by the banks not captured by the model and that might be correlated with fluctuations in leverage around the election, the most relevant of which is demand for hedging against fluctuations in the exchange rate. The IV also helps eliminate the concern that the specie-asset ratio might include silver in the numerator. We verify it is a strong instrument, with a regression F-statistic over 13. Column 3 shows the corresponding IV estimate. In all cases, the regression coefficients are statistically significant in spite of our small sample. Column 4 includes some controls that capture other possible variations across states. The controls include the state bank fraction of all bank assets in each state, the fraction of national bank assets held in reserves, the (log) population, the fraction of the population that is urban, the fraction of agricultural production in total production (see Appendix C for their construction and sources). We further control for whether or not states are on the eastern seaboard as a way to capture the role of exposure to foreign trade in determining the observed correlations. The explanatory power of the specie/asset ratio before 1890 is largely unchanged, again suggesting that gold is the primary explanation for the differences across states. Appendix Table A-1 shows the main regressions in Table 1, but includes bonds to secure circulation in our definition of assets and reaches reach similar results.

Table 2 shows the relationship between leverage changes around the 1896 election and leverage changes at other important dates during the period. We include the same controls as in Table 1 column 4 for both 1896 and the comparison year to help absorb changes in the real and financial economy at different periods. All of the results are robust to not including controls (see Appendix

Table 2: The Change in Bank Leverage Around the 1896 Election and other dates

	Dep. var: Change in bank leverage in 1896 election				
	(1)	(2)	(3)	(4)	(5)
Independent variable:	OLS	OLS	OLS	OLS	OLS
Change in bank leverage	0.0366				
McKinley Assassination	(0.0757)				
Change in bank leverage		0.0207			
1907 Panic		(0.0329)			
Change in bank leverage			0.0621*		
1900 Election			(0.0317)		
Change in bank leverage				0.217***	
1888 Election				(0.0558)	
Change in bank leverage					0.0357
1888 Commodity Shock					(0.0608)
Additional controls	Yes	Yes	Yes	Yes	Yes
N	48	48	49	43	43
R-squared	0.407	0.400	0.444	0.648	0.449

Notes: This table shows how the change in bank leverage (debt/assets) across states around the 1896 election is related to the change at other dates. See Table 1 for the other control variables. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A-2). Column 1 examines whether the 1896 pattern may have reflected the fact that Bryan was generally perceived as antibusiness by comparing the change in leverage at the time of the assassination of McKinley and the succession of Theodore Roosevelt, who was similarly perceived to have skepticism of large businesses. Column 2 shows a regression of the change in bank leverage in different states around the 1896 election on the changes in leverage around the 1907 bank panic. The latter episode was marked not only by widespread bank suspensions with the emergence of premia between currency and bank payments, but also by uncertainty about the ability of banks to pay depositors, providing a reasonable comparison point for the cross-state impact of a generalized "liquidity" shock to the banking system. Columns 3 and 4 provide similar regressions using alternative election dates on the right-hand side to control for the effect of other common elements of the party platforms, most notably tariff policies.[13] Column 5 compares the cross-section of bank

[13] In 1900, gold was still an issue but was much less prominent, while tariffs and the recent Spanish-American War were priorities. The 1888 election was close and tariffs were the leading economic plank of both parties while gold was given much less prominence (see `http://www.presidency.ucsb.edu/platforms.php` for the party platforms).

leverage changes to those that happened between June 30 and October 4, 1888, a period in which wheat prices grew by 36%.[14] All of the regressions except the ones on election years yield statistically insignificant coefficients, suggesting that the pattern of changes in leverage across states in the 1896 election comes from the increase in credibility, rather than other changes in policies or macroeconomic events. The coefficient on the change in leverage around the 1888 election is highly significant. We show in Section 5, however, that formally controlling for that election has very little bearing on the behavior of a credibility index constructed following the method in Section 2. We examine additional specifications in Appendix Table A-2, which shows that including leverage lagged by a year or not including any controls yields the same conclusions.

To summarize, the evidence suggests the election increased bank leverage more in states where gold was more available. This finding is consistent with the model, as is the finding that leverage increased overall. Moreover, the pattern observed around the 1896 appears to be fairly distinct from the pattern observed in other important junctures. In the next section, we use the heterogeneous effect of the natural experiment from the election to identify the impact that fluctuations in credibility had over a broader period.

5 The Credibility Index

We now construct an index for the credibility of the gold standard by identifying a latent factor using the procedure delineated in Proposition 1 in Section 2. We take December 1896 (1896/12) as the reference date t_1, which amounts to assuming that the only nationwide shock of importance around the election was a change in commitment to gold. In Section 3, we provide support for Assumption 1 based on narrative evidence. Assumption 2 requires that state characteristics that make states more or less vulnerable to other macroeconomic shocks are uncorrelated with their exposure to shocks to the credibility of the gold standard. The assumption is consistent with the analysis in Section 4.3 implying only weak correlations between the cross section of state-level leverage changes around the 1896 election and the changes around other key dates. We provide

[14] The growth rate between the months of June and October 1888 was calculated from the "U.S. Wholesale Price of Wheat, Chicago, Six Markets 07/1841-07/1944" series available in the NBER Macrohistory database.

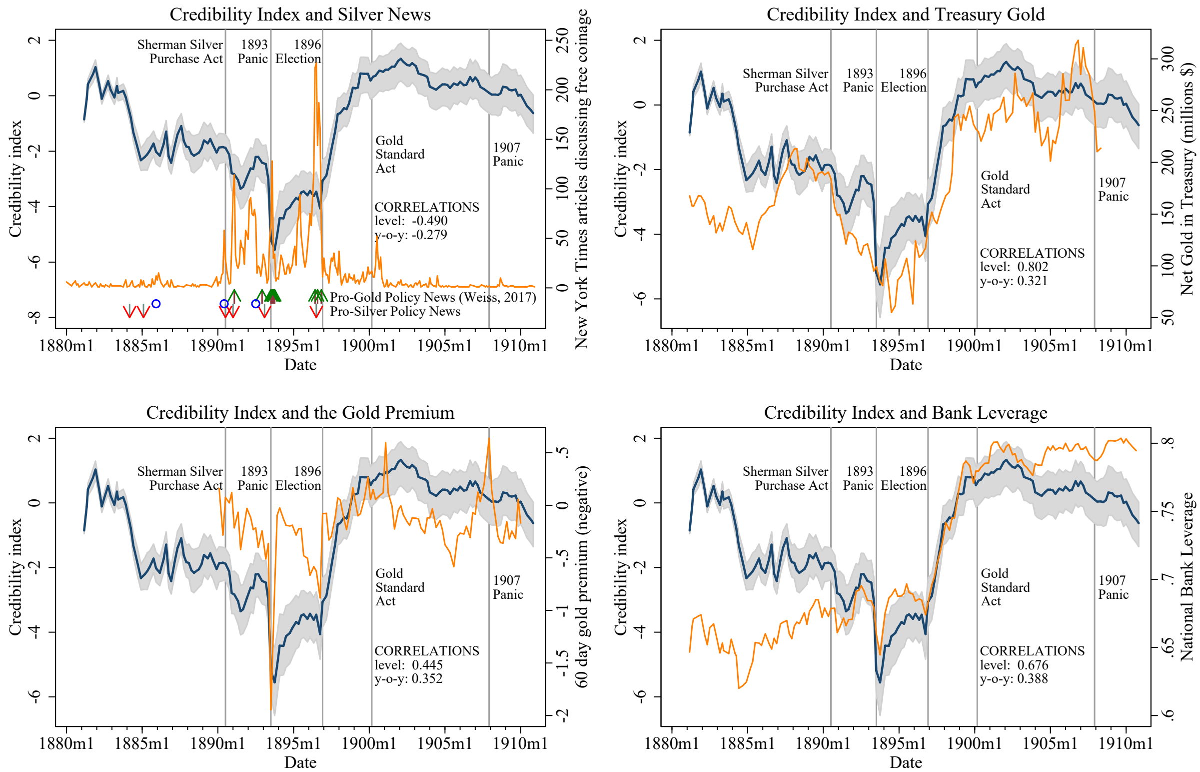
further support to both Assumptions 1 and 2 by relying on Proposition 2 to allow for control episodes, which we discuss in more detail below. As we later show, the introduction of these episodes does little to affect our baseline results.

To construct the index, we estimate a factor model using as our informational variables the seasonally adjusted log changes in the bank debt-to-assets ratio in 48 states for which continuous time series are available. Since we extract information from changes in balance sheets, we take the identified factor to correspond to changes in credibility. The index is therefore the cumulative sum of the estimated latent factor over time. To choose the number of principal components in the estimate, we calculate the ICP_1 and ICP_2 indices from Bai and Ng (2002). The number of factors that minimize the two indices are, respectively, 11 and 4. We take a conservative stance and calculate the index based on 11 factors for our baseline calculations. We use the Bayesian Information Criterion to choose the number of lags for the process governing the evolution of the factors themselves. As it turns out, the criterion is minimized with zero lags, so that in our baseline implementation we take the factors to be i.i.d.[15]

Figure 3 depicts the time path of our baseline index together with a 90 percent confidence interval constructed through bootstrapping. Each panel of Figure 3 compares the index to a different measure from the period: a measure of the extent of silver agitations, the amount of gold in the Treasury, the premium on gold-denominated assets, and national-bank leverage. The first noteworthy feature of the time series for the index shown in Figure 3 is that it is relatively volatile up to around 1900, after which it becomes very stable: the standard deviation of changes in the index are only 28 percent as large after February 1900 as before. The change in volatility coincides with the passage of the Gold Standard Act, which, as noted in Section 3 above, increased the legal requirement as well as provided for increased means for the Treasury to maintain the convertibility between the U.S. dollar and gold. This large reduction in volatility provides a strong indication that changes in expected devaluations played a key role in driving the index before 1900. Appendix

[15]The number of factors implied by the Bai and Ng criterion is sensitive to whether or not we normalize the individual time series by their variance. We decided against normalization since all the time series refer to the behavior of the same variable in different geographic locations. For a given number of factors, the results are not very sensitive to the normalization choice.

Figure 3: The credibility index, silver in the news, Treasury gold, the gold premium, and bank leverage



Notes: This figure compares the credibility index to other measures of credibility and bank leverage. The correlations are for the two series (level) and the year-on-year changes (y-o-y). Shaded area shows two standard deviations of the changes in the credibility index. Gold in Treasury is from the Annual Report of the Secretary of the Treasury in 1900 and 1908. The gold premium axis is flipped and is calculated from National Monetary Commission (1910, pp. 188-208) following Calomiris (1992). The Silver News is the number of articles each month in the *New York Times* discussing "free coinage." The arrows show dates that Weiss (2017) identifies as policy news changes for or against silver coinage (circles indicate dates where both positive and negative news occurred between call dates). Bank leverage is debt/assets calculated by authors from Weber (2000).

Figure A-6 shows that an index constructed comparing the top 10 specie/assets states before 1890 to the bottom states produces similar movements to our credibility index.

Apart from the change in volatility after 1900, the index also exhibits strong movements around two episodes that the historical narrative identifies as critical political events affecting the credibility of the gold standard. The first is the passage of the Sherman Silver Purchase Act in 1890, which was widely regarded as damaging to the credibility of the standard and which is associated with a strong reduction in the index. The second is the three-year period following the election in November 1896. While the change in the index was positive by construction right around the election, it is also noteworthy that it remained on a strongly increasing path. This continuing increase is associated with other important events at the time that consolidated the adherence of the U.S. to the gold standard, notably the verification that there were large gold reserves to be exploited in Alaska and the increase in worldwide supply of gold following the progressive adoption of the cyanide process of gold extraction.[16] This correspondence to the historical narrative is further confirmed by a direct measure of the extent to which free coinage was mentioned in newspaper articles, introduced in Section 3.1 and shown in the top left panel of Figure 3. It is in periods when discussion of "free coinage" was at its highest that the credibility index was most volatile.

It is also noteworthy that the credibility index dips around the 1884 and 1893 banking panics, suggesting that those panics were associated with a strong decrease in the credibility of the gold standard. This is in line with narratives of the period. Around both 1884 and 1893, the ability of the Treasury to honor its commitments in gold as opposed to silver was put in question. For example, Noyes (1909, p. 103) quotes a Treasury Report concerning the 1884 panic: "a panic or an adverse current of exchange might compel ... the use of silver or silver certificates in the payment of [the Government's] gold obligations." Likewise, as described in Section 3 above, the 1893 panic was also a period of considerable uncertainty about the ability of the government to honor its gold-denominated obligations.[17]

These narratives are buttressed by the top right panel of Figure 3, showing a comparison of the index with the amount of gold held by the Treasury as reported by the Annual Reports of the Secretary of the Treasury in 1900 and 1908. One might expect the amount of gold held by the Treasury to be correlated with commitment to the gold standard for two reasons. First, as emphasized by Grilli (1990), higher gold reserves give the Treasury more "fire power" to defend the gold standard in the event of a speculative attack. Second, an increase in the probability of an exit from the gold standard would be an incentive for agents to redeem gold from the Treasury in exchange for dollars, depleting gold reserves. The correlation between the two measures is 80

[16]Friedman (1994), Ch. 5, has an account of how the cyanide process contributed to Bryan's political decline between 1896 and 1900.

[17]The index also confirms that the low coefficients reported in columns 5 through 9 in Table 1 are not a consequence of noise introduced by idiosyncratic variation. Inspection of the panels in Figure 3 confirms that there is very little variation in the index around other elections, the death of McKinley in 1901, or the 1907 panic.

percent, with both series peaking together in the beginning of 1889, bottoming around the 1893 panic, and rising again after the 1896 election. Furthermore, the correlation is not restricted to low-frequency fluctuations. If converted to yearly changes, the correlation is a smaller, but still high, 35 percent.

The bottom left panel of Figure 3 compares the index to an alternative measure of commitment: the "gold premium" as calculated by Calomiris (1992), which we extend using the original source (National Monetary Commission, 1910) (see Appendix C for details). Assuming uncovered interest parity holds, the gold premium gives the expected appreciation of the dollar relative to pound sterling within 60 days. Like our index, the gold premium drops abruptly around the 1893 panic and right before the 1896 election, after which it switches to a higher and more stable path (note that we invert the gold premium axis to make the series more comparable). The discrepancy between the two series may reflect the differences between highly informed investors in New York and London arbitraging between two short-term assets and less-informed depositors deciding how to allocate their endowments throughout the country. Also, while our series is consistent with segmented markets in which uncovered interest parity need not hold, the gold premium series strictly relies on such parity.[18]

We relax Assumptions **1** and **2** by recalculating the index using the procedure laid out in Proposition 2, taking the cross-sectional pattern of behavior of changes in banking leverage in periods when other shocks were likely to have been particularly important as controls. Specifically, we use as controls the dates in Table 1, since, as described in Section 4.3, they capture prominent macroeconomic shocks that happened in periods when there was less instability in the credibility of the gold standard.[19] As a robustness check, we also control for a one-year (five call-date) window around the 1907 panic and the 1888 agricultural shock to take account of the fact that those events unfolded over the course of several months.

[18]See Coleman (2012) for a recent detailed discussion of the failures of uncovered interest parity at the time.

[19]Given the large gold movements around the 1907 panic, one could wonder whether it is appropriate to assume that issues surrounding the credibility of the gold standard were resolved. The behavior of the gold premium in Figure 3 suggest that they were. The rise in the gold premium around the 1907 episode is consistent with the description of stabilizing speculative behavior in Eichengreen (1992) for economies that did not have their adherence to the gold standard in question. In those instances, monetary scarcity requiring gold imports from abroad would be matched with a relative decrease of the domestic interest rate, consistent with expected appreciation of the dollar relative to gold.

Table 3: Robustness of different approaches to calculating the credibility index

			Change in credibility index during:		
Credibility index calculated using:	Correlation with baseline	st. dev. Pre-1900/ st. dev. Post-1900	Year following Sherman Act	Year following 1896 election	Trough of 1893 crisis
Baseline	1	0.34	-1.38	2.97	-1.91
	(1,1)	(0.331,0.391)	(-1.57,-1.14)	(2.6,3.18)	(-2.03,-1.64)
Control for	0.989	0.382	-1.18	2.67	-1.74
1907 panic	(0.937,0.999)	(0.349,0.472)	(-1.45,-0.887)	(2.26,2.91)	(-1.91,-1.5)
Control for	0.966	0.294	-1.63	3.48	-2.12
1888 election	(0.945,0.985)	(0.284,0.336)	(-1.82,-1.28)	(2.89,3.76)	(-2.32,-1.79)
Control for	0.984	0.294	-1.69	3.32	-2.05
1900 election	(0.962,0.998)	(0.287,0.336)	(-1.96,-1.37)	(2.92,3.6)	(-2.24,-1.8)
Control for ag. shock	0.999	0.358	-1.32	2.89	-1.88
(Oct. 1888)	(0.987,1)	(0.332,0.413)	(-1.64,-1.01)	(2.55,3.14)	(-2.11,-1.6)
Control for McKinley	0.969	0.302	-1.55	3.48	-2.14
assassination (Sep. 1901)	(0.933,0.996)	(0.289,0.345)	(-1.79,-1.25)	(3.02,3.76)	(-2.34,-1.83)

Notes: This table shows possible variations in the latent factor index using different numbers of factors and including additional control dates. 90 percent confidence intervals in parentheses calculated using bootstrapping.

Table 3 depicts the results of the robustness exercise. After the row showing the baseline, the next five rows correspond to results obtained by including different controls. We find that the index remains largely unchanged. The first column shows the correlation between the index calculated under different assumptions and our baseline (90 percent confidence intervals based on a bootstrap are presented below each statistic, in parentheses). The correlation is uniformly high, above 95 percent in most cases. In Appendix Table A-3 we show additional robustness checks: indices calculated using 5 and 20 factors instead of 11, and controlling for the 1888 agriculture shock and 1907 panic using five call-dates control windows instead of just one. The results are similar, although the correlation with our baseline index using the windows is somewhat lower. Even with such stringent controls, the correlation is significantly positive, which we take as a sign of robustness of our baseline estimate. The second column shows the ratio between the volatility of changes in the index after and before 1900. In all cases, the ratio is close to 25 percent, implying that the index varied four times as much before the formal adoption of the gold standard as after. Columns 3 through 5 show the change in the index following the three main historical events that we highlighted above: the year after the passing of the Sherman Silver Purchase Act in 1890, the year after the 1896 election, and the trough of the 1893 crisis. The ability of the index to capture these key episodes is robust to changing the number of factors or to the addition of controls.

Together, the comparisons of the index with the historical narratives and with other variables that are likely to be correlated with exchange rate expectations, as well as the various robustness exercises lend credence that Assumptions **1** and **2** provide a basis for the construction of an index of the credibility of the government's commitment to the gold standard.

6 The Economic Impact of Imperfect Commitment

We now use the credibility index to evaluate the economic impact of imperfect commitment throughout the turn of the 20th century. Within the context of the model in Section 4.3, loans increase with deposits, so that there is link between the credibility of the exchange rate and banking intermediation. Individuals at the time clearly felt such links existed. Before the election, there had been substantial concern about what a Bryan win and "free silver" would do to financial and business activity (see, for example, Appendix Figure A-7). After the election, these concerns were allayed: "The universal feeling among the advocates of sound money that with the election of McKinley thorough confidence in the large business centers would at once be re-established and that factories long idle would be run on full time again . . . ."[20] A similar sentiment was apparent in both Chicago and San Francisco, where at least a part of the reason was because banks seemed increasingly willing to lend: "To-day banks are willing to lend, merchants are seeking to borrow, and customers are placing their orders where a week ago there was no lending nor borrowing and little buying."[21] In this section, we use the credibility index to investigate some of these claims.

The bottom right panel of Figure 3 shows the time series for the index, overlaid with the time series for leverage of national banks, aggregated across all states. The two are highly correlated. There is no noticeable reduction in leverage following the Sherman Silver Purchase Act, but otherwise the two series share similar peaks and troughs. This correlation suggests that even if changes in commitment to gold did not explain all fluctuations in leverage over the period, they played a key role in the increase in bank leverage after 1896 and the reduction in volatility after 1900. Importantly, this close relationship does not emerge by construction. Rather, the index is identified by how similar the changes in the cross-section across states to the changes in the election of 1896, not by the aggregate time series.

The stability of leverage around the Sherman Silver Purchase Act can be traced to other shocks that happened around the same period. In 1889, the U.S. had a bumper wheat crop, and Congress passed the McKinley Tariff Act and appropriation bills that increased expenditures (Noyes, 1909, p. 156). Another major exception to the correlation occurs in the aftermath of the 1884 panic when bank leverage slowly recovers even as the credibility shock appears to have dropped persistently. The reason is likely that banks were in a particularly strong liquidity situation prior to the panic

[20]"A Boom in Business", *New York Tribune*, Nov. 5, 1896, p. 7. In ProQuest Historical Newspapers: New York Tribune (1841-1922).

[21]"Prosperity's Return to California," *San Francisco Chronicle*, Nov. 10, 1896, p. 9; in ProQuest Historical Newspapers: San Francisco Chronicle (1865-1922). Other individuals quoted in the article had similar beliefs. Individuals in Chicago had similar views, see "Hoarded Gold Is Coming Out: First Deposits of the Yellow Metal for Months Made at the Banks," *Chicago Daily Tribune*, Nov. 5, 1896, p. 12; in ProQuest Historical Newspapers: Chicago Tribune (1849-1990).

due to an artificial injection of silver dollars under the Bland-Allison Act (Sprague, 1910).

How important was the lack of commitment to the gold standard for real economic activity? The close relationship with leverage and the observations of contemporaries suggests a potentially large effect. To assess the impact of fluctuations in commitment on economic activity, we estimate the effect of changing commitment on four measures of real activity, for which high-frequency (monthly or quarterly) data are available: (i) the number of business failures tabulated by the NBER with data originally collected by Bradstreet's, (ii) pig-iron production as tabulated by Macaulay (1938) from weekly capacity of blast furnaces, (iii) industrial production as calculated by Miron and Romer (1990) (both the raw and "smoothed" series), and (iv) factory employment as calculated by Jerome (1926).

For each measure, we first estimate a two-variable vector autoregression (VAR) including log-changes in the measures of economic activity and changes in the relative return index.[22] Given that the data are available at five call dates per year, we include five lags.[23] To identify the effects of shocks to credibility, we then take two extreme identification approaches. In one, we assume that exogenous shocks to the commitment to the gold standard do not have an immediate impact on the measures of economic activity but that the converse is true. This is a plausible assumption if we take the relevant economic variables to be relatively slow moving while allowing credibility to react quickly. We label this identification assumption "fast" and take it as our baseline. In the other, "slow," identification assumption, we assume that shocks to the different measures of economic activity do not have any immediate impact on credibility. This assumption amounts to viewing fluctuations in the government's commitment to the gold standard as largely exogenous to economic events over the short run.

Given the identification of shocks, we then construct counterfactual time series for the measure of economic activity under perfect commitment to the gold standard. We obtain the counterfactual by calculating an alternative sequence of structural shocks to the index that ensures it remains

[22]For parsimony, we only include the two variables in the VAR, which remains agnostic regarding the transmission channel through the banking system.

[23]In appendix Table A-4, we show the results that would have been obtained with 10 lags and do not find any discernible differences.

Table 4: Macroeconomic implications of lack of commitment to peg

Measure of economic activity	Speed of response of credibility	Counterfactual assuming full commitment: Relative volatility before 1900	Relative volaty after 1900	Counterfactual change in measure Mar–Oct 1893	Actual change in measure Mar–Oct 1893
Business failures	fast	0.79	1.04	0.253	1.01
		(0.777,0.839)	(0.99,1.14)	(0.145,0.364)	
	slow	0.887	1.05	0.429	1.01
		(0.862,0.968)	(0.996,1.15)	(0.231,0.645)	
Pig iron	fast	0.882	0.968	-0.348	-0.578
		(0.855,0.951)	(0.948,1.03)	(-0.383,-0.306)	
	slow	0.928	0.966	-0.441	-0.578
		(0.897,1.01)	(0.949,1.03)	(-0.474,-0.4)	
Factory employment	fast	0.831	0.98	-0.0582	-0.155
		(0.813,0.896)	(0.961,1.06)	(-0.0715,-0.0445	
	slow	0.853	0.993	-0.0918	-0.155
		(0.845,0.911)	(0.977,1.08)	(-0.105,-0.0762)	
Industrial production	fast	0.971	0.958	-0.0803	-0.196
		(0.909,1.1)	(0.944,1.03)	(-0.104,-0.0586)	
	slow	0.968	0.983	-0.111	-0.196
		(0.907,1.09)	(0.962,1.06)	(-0.137,-0.087)	
Smoothed industrial production	fast	0.874	0.952	-0.0742	-0.157
		(0.843,0.951)	(0.891,1.06)	(-0.093,-0.0548)	
	slow	0.898	0.951	-0.102	-0.157
		(0.864,0.982)	(0.89,1.07)	(-0.121,-0.0803)	

Notes: This table shows the results of a VAR including each real measure of economic activity and the credibility index under different identification assumptions. In the "fast" identification assumption, credibility reacts immediately to economic activity, while economic activity responds only with a lag; in the "slow" identification assumption, credibility reacts only with a lag, while economic activity responds immediately to changes in credibility. The relative volatility is how much the volatility of the real measure would decline if there had been no volatility in credibility. The change in the measure shows how much the measure increased or decreased under our counterfactual without credibility uncertainty and the actual change during the worst period of the 1893 depression. 90 percent confidence intervals calculated using bootstrapping. The sample periods are constrained by data availability and run from 1881 to 1920 for pig iron, 1884 to 1910 for industrial production (raw and adjusted), 1882 to 1910 for business failures, and 1889 to 1910 for factory employment. All variables are seasonally adjusted.

constant throughout the period while keeping other structural shocks at their historic path. Table 4 shows summary statistics for the baseline results. The standard errors are bootstrapped so as to take into account the fact that the credibility index is a generated regressor. For each measure of economic activity, we present results with the two alternative identification schemes.

The first two columns show the volatility of changes in the counterfactual measure of economic activity relative to the actual historical experience before and after the formal adoption of the gold standard in 1900. As discussed extensively in Section 3 above, 1900 is a natural breakpoint due to the passage of the Gold Standard Act. In contrast, the resolution of the money question in 1896 was temporary, since it showed that there was a clear constituency for the abandonment of the gold standard and which could plausibly still win subsequent elections.

Before 1900, the volatility of changes in business failures would be 21 percent lower for the "fast" identification scheme (11 percent in the "slow" one). Numbers for the volatility of change in pig-iron production, factory employment, and industrial production are somewhat smaller, at 18 percent (8 percent), 17 percent (15 percent), and 3 percent (3 percent), respectively. In all cases except for the raw industrial production index, the results imply that complete stabilization of the credibility of the exchange rate would yield a statistically significant reduction in the volatility of economic activity. Miron and Romer point out that the Miron and Romer (1990) index is much more volatile than the analogous Federal Reserve index in the period of overlap. For that reason, they also make available an alternative industrial production index that is smoothed and seasonally adjusted. This alternative yields results more in line with the other indicators in the table.[24]

The post-1900 period acts as a placebo test. Table 4 shows that eliminating shocks to credibility after 1900 does not change the volatility of real activity in a statistically significant manner. The index matters when it should and does not when credibility was much less in question. Appendix Figure A-8 illustrates these results. It shows the (detrended) economic measure used in the VAR and the difference in that measure under the "fast" counterfactual removing volatility in credibility. Before 1900, it is clear that the counterfactual is acting strongly to dampen both upswings and

[24]The alternative index is available from Miron and Romer here: `https://eml.berkeley.edu/~cromer/#data`, accessed 30 September 2018.

downswings in each economic measure. After 1900, and particularly during the 1907 financial crisis, there is no longer any dampening.

The last two columns of Table 4 present the implication of the counterfactual calculations for the 1893 depression, which was the prominent macroeconomic event of the period. In the "fast" identification scheme, the point estimates imply that fluctuations in the commitment to the gold standard account for close to 75 percent of the rise in business failures between March and October 1893, 40 percent of the reduction in pig-iron production, 62 percent of the fall in employment, and 59 percent of the fall in industrial production. Under the slow identification scheme, the lack of commitment to the gold standard accounts for a smaller, but still substantial, fraction of the drop in economic activity in that period, ranging from 23 percent of the fall in pig-iron production to 57 percent of the increase in business failures. In summary, the VAR analysis indicates that the lack of credibility of the exchange rate peg had a significant impact on output volatility in the last decades of the 19th century and played a key role during the 1893 panic.[25]

7 Conclusion and Discussion

We develop a methodology to learn from a single event (the 1896 election) about aggregate impacts of the corresponding shock. We find evidence that the prospect of a devaluation can be costly for an economy even if the devaluation does not ultimately occur. While the structure of the U.S. economy at the end of the nineteenth century differs from economies today, the banking sector and international finance played a sufficiently prominent role that the episode ought to be informative for policymakers today, as illustrated by the recent instability around the European Monetary Union.

One key difference between modern economies and the one we analyze is the presence of a central bank with the ability to set interest rates and "defend" currency pegs in that manner even once foreign exchange reserves are lacking. In contrast, before the passage of the Gold Standard

[25]This counterfactual exercise is vulnerable to the Lucas critique. As an additional measure of robustness, we also calculate the counterfactual using VAR coefficients estimated using the post-1900 subsample and present those exercises in Appendix Table A-5.

Act in 1900, once Treasury's gold reserves were depleted, exchange rate intervention required Treasury to obtain an authorization from Congress to issue bonds in order to replenish its reserves. This additional political step—and continuing political intervention in the peg—contributed to the lack of credibility we find prevailed before 1900, most notably during the 1893 crisis. As such, our findings reinforce that the best way to stabilize an exchange rate peg is to keep, to the extent possible, the management of exchange rates independent from the political process.

Of course, exchange rate crises are often self-fulfilling credibility crises: as concerns mount about exchange rate credibility, so do the costs of maintaining a peg, leading to greater concerns about credibility. A major contribution of our work is to develop a method that cleanly distinguishes the costs of credibility in a particular episode that does not include the costs of the devaluation that often follows. By doing so, we show that lack of credibility can be very costly by itself. It may be better to either fully commit, or devalue early, rather than bear the potentially large costs of a lingering lack of credibility.

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A Factor Identification: Proofs

The proofs take as given that the sample moments are consistent estimators of the population moments, and that the data are large enough that they have converged.

Proof of Proposition 1: The proof follows from direct calculation. Let Λ be the $N \times R$ matrix of factor loadings, with entries $\lambda_{i,r}$. Given $\bar{x}_t = \sum_{r=1}^{R} \lambda_{i,r} F_{r,t}$, it follows that:

$$cov\left(\bar{x}_t, \bar{\nu}_{t_1}\right) = \sum_{r=1}^{R} \sum_{r'=1}^{R} cov\left(\lambda_{i,r}, \lambda_{i,r'}\right) \nu_{r',t_1} F_{r,t}.$$

Given Assumption 1, all the terms with $r' \neq 1$ are equal to zero, so that:

$$cov\left(\bar{x}_t, \bar{\nu}_{t_1}\right) = \sum_{r=1}^{R} cov\left(\lambda_{i,r}, \lambda_{i,1}\right) \nu_{1,t_1} F_{r,t}.$$

Given Assumption 2, all the terms with $r \neq 1$ are also equal to zero so that:

$$cov\left(\bar{x}_t, \bar{\nu}_{t_1}\right) = var\left(\lambda_{i,1}\right) \nu_{1,t_1} F_{1,t}.$$

Finally, we can also calculate

$$var\left(\bar{\nu}_{t_1}\right) = var\left(\lambda_{i,1}\right) \nu_{1,t_1}^2.$$

By taking the ratio of the expressions for $cov\left(\bar{x}_t, \bar{\nu}_{t_1}\right)$ and $var\left(\bar{\nu}_{t_1}\right)$, we obtain:

$$\frac{cov\left(\bar{x}_t, \bar{\nu}_{t_1}\right)}{var\left(\bar{\nu}_{t_1}\right)} = \frac{F_{1,t}}{\nu_{1,t_1}}.$$

Proof of Proposition 2: Given $\bar{x}_t = \sum_{r=1}^{R} \lambda_{i,r} F_{r,t}$ the OLS regression coefficients $\alpha_{k,t}$ satisfy for each t,

$$\min_{\{\alpha_{k,t}\}_{k=1}^{K}} \sum_{i=1}^{I} \left(\bar{x}_{i,t} - \sum_{k=1}^{K} \alpha_{k,t} \sum_{r} \lambda_{i,r} \nu_{r,t_k} \right)^2.$$

The F.O.C.'s are:

$$\sum_{i=1}^{I}\left(\bar{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\sum_{r}\lambda_{i,r}\nu_{r,t_{k'}}\right)\sum_{r}\lambda_{i,r}\nu_{r,t_k}=0\;\forall k\in\{1,...,K\}.$$

Let $\hat{x}_{i,t}\equiv\sum_{r=1}^{K}\lambda_{i,r}F_{r,t}$ and $\tilde{x}_{i,t}=\sum_{r=K+1}^{R}\lambda_{i,r}F_{r,t}$, and similarly define $\hat{\nu}_{i,t}$ and $\tilde{\nu}_{i,t}$. Then we can rewrite the F.O.C.'s as:

$$\sum_{i=1}^{I}\left[\begin{array}{c}\left(\hat{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\hat{\nu}_{i,t_k}\right)\hat{\nu}_{i,t_k}+\left(\tilde{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\tilde{\nu}_{i,t_{k'}}\right)\hat{\nu}_{i,t_k}\\+\left(\hat{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\hat{\nu}_{i,t_k}\right)\tilde{\nu}_{i,t_k}+\left(\tilde{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\tilde{\nu}_{i,t_{k'}}\right)\tilde{\nu}_{i,t_k}\end{array}\right]=0\;\forall k\in\{1,...,K\}.$$

Assumption 2' states that if $r\leq K$ and $r^{'}>K$, then $\sum_i\lambda_{ir}\lambda_{ir'}=0$ (this is equal to the covariance of factor loadings, since they average to zero). It follows that for any t, $t^{'}$, $\sum_{i=1}^{I}\hat{x}_{i,t}\tilde{x}_{i,t'}=0$, since:

$$\begin{aligned}\sum_{i=1}^{I}\hat{x}_{i,t}\tilde{x}_{i,t'}&=\sum_{i=1}^{I}\sum_{r=1}^{K}\sum_{r'=K+1}^{R}\lambda_r^i\lambda_{r'}^iF_{r,t}F_{r',t'}\\&=\sum_{r=1}^{K}\sum_{r'=K+1}^{R}\left(\sum_{i=1}^{I}\lambda_r^i\lambda_{r'}^i\right)F_{r,t}F_{r',t'}=0,\end{aligned}$$

and similarly $\sum_{i=1}^{I}\hat{\nu}_{i,t}\tilde{\nu}_{i,t'}=0$. Thus, the F.O.C.'s reduce to:

$$\sum_{i=1}^{I}\left[\left(\hat{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\hat{\nu}_{i,t_{k'}}\right)\hat{\nu}_{i,t_k}+\left(\tilde{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\tilde{\nu}_{i,t_{k'}}\right)\tilde{\nu}_{i,t_k}\right]=0\;\forall k\in\{1,...,K\}.$$

Assumption 1' states that for all k, $\nu_{r,t_k}=0$ for $r>K$, so that $\tilde{\nu}_{i,t_k}=0$. Thus, we can write the F.O.C. as:

$$\sum_{i=1}^{I}\left[\left(\hat{x}_{i,t}-\sum_{k'=1}^{K}\alpha_{k',t}\hat{\nu}_{i,t_{k'}}\right)\hat{\nu}_{i,t_k}\right]=0\;\forall k\in\{1,...,K\}.$$

Rewrite this as:

$$\sum_{i=1}^{I}\left[\left(\sum_{r=1}^{K}\lambda_{i,r}F_{r,t}-\sum_{k'=1}^{K}\alpha_{k',t}\sum_{r=1}^{K}\lambda_{i,r}\nu_{r,t_{k'}}\right)\hat{\nu}_{i,t_k}\right]=0\;\forall k\geq 2.$$

Take the $\lambda_{i,r}$ out so that:

$$\sum_{i=1}^{I}\sum_{r=1}^{K}\lambda_{i,r}\left[\left(F_{r,t}-\sum_{k'=1}^{K}\alpha_{k',t}\nu_{r,t_{k'}}\right)\right]\hat{\nu}_{i,t_k}=0\;\forall k\in\{1,...,K\}.$$

The equation will hold exactly if $F_{r,t} = \sum_{k'=1}^{K} \alpha_{k',t} \nu_{r,t_{k'}}$ for all r. Let $\hat{\nu}_{\{k\}}$ be a matrix with entry ν_{r,t_k} in row r, column k, $\hat{F}_t$ be the vector with entry $F_{r,t}$ in row r, and $\alpha_t = \{\alpha_{1,t}, \alpha_{2,t}, ..., \alpha_{K,t}\}$. Then, we can express the system of equations as $\hat{\nu}_{\{k\}} \alpha_t = \hat{F}_t$, and so long as $\hat{\nu}_{\{k\}}$ is invertible (Assumption 4), the F.O.C. will hold for:

$$\alpha_t = \hat{\nu}_{\{k\}}^{-1} \hat{F}_t.$$

Now, following Assumption 3, suppose that $\nu_{1,t_1} > 0$ but $\nu_{1,t_k} = 0$ for $t_k \neq t_1$. Then the first line of the system of equations reduces to:

$$\alpha_{1,t} = \frac{F_{1,t}}{\nu_{1,t_1}}.$$