Searching for Irving Fisher

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There is a long-standing debate as to whether the Fisher effect operated during the classical gold standard period. We break new ground on this question by developing a market-based measure of general inflation expectations during the gold standard. Since the gold-silver price ratio was a widely used measure of inflation expectations during the gold standard period, we are able to derive a measure of inflation expectations using the interest-rate differential between Austrian silver and gold perpetuity bonds with identical terms. Our empirical evidence suggests: (1) inflation expectations exhibited significant persistence at the weekly, monthly, and annual frequencies; (2) market participants forecast a significant portion of both the gold deflation and inflation episodes during the classical gold standard period; and (3) inflation expectations are highly correlated with nominal interest rates. We find evidence in favor of the operation of both a short and long-run Fisher effect during the classical gold standard period.

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Several studies have found that *ex post* inflation rates are uncorrelated with the level of nominal interest rates during the classical gold standard period even though the Fisher equation is an empirical relationship based on inflation expectations.[1] One possible explanation for the failure of the Fisher equation in this earlier period is that inflation expectations were nearly zero given the low level of persistence in annual measures of *ex post* inflation rates (Barsky, 1987; Bordo and Kydland, 1995; Fisher, 1930; Friedman and Schwartz, 1982).[2] Other possible explanations for the lack of correlation between nominal interest rates and inflation rates include the hypotheses that financial markets had money illusion or that investors did not understand the quantity theory of money (Summers, 1983; Cagan, 1984; Choudry, 1996; Barsky and Delong, 1991).

Several scholars have attempted to estimate price and inflation expectations during the gold standard period to test for the presence of a Fisher effect using time series econometric models (Capie, Mills, and Wood, 1991). An obvious limitation to this approach is that we do not have a very good idea of the economic model that market participants used to form inflation expectations (Barsky and DeLong, 1988). Alternatively, some more recent studies have used data on agricultural futures to derive a measure of inflation expectations (Siegler and Perez, 2003). However, as noted by the authors, trading in futures markets was quite thin during the gold standard and estimation

[1] Many studies have found that nominal interest rates during the gold standard are correlated with the price level rather than the rate of inflation. Barsky and Summers (1983) argue that that this positive correlation is a direct result of the fact that the price level in the inverse of the price of gold. Benjamin and Kochin (1984) argue that Gibson's Paradox during this period is a spurious relationship.

[2] For a discussion of inflation expectations during the gold standard period, see Barsky and DeLong (1983). For an analysis of the persistence of inflation during the gold standard period and later, see Burdekin and Siklos (1996). Harley (1977) analyzes prices and interest rates in the UK during the gold standard period to test Gibson's Paradox.

sometimes requires interpolation techniques to construct a continuous times series. In addition, agricultural futures only cover individual commodities, and hence are based on the assumption that agricultural prices track the overall inflation rate. This approach suffers from a failure to distinguish between changes in relative prices versus changes in the overall price level (Bordo and Schwartz, 1981). Summarizing the literature, McCallum (1984) points out that studies of pre-World War I changes in the price level have simply shown that past inflation cannot forecast future inflation and therefore say very little about inflation expectations or the failure of the Fisher effect during the gold standard period.

To improve upon the existing literature, we have collected high-frequency asset price data that allow us to compute a market-based measure of inflation expectations for the 19th century. In particular, we use data on Austrian gold, silver, and paper government bonds to compute measures of inflation expectations at high and low frequencies during the classical gold standard period to test for the presence of a short and long-run Fisher effect. Austria was the only major European country during the classical gold standard period that issued gold, paper, and silver perpetuity bonds that actively traded on the leading financial exchanges of Europe including London, Paris, Berlin, Amsterdam and Vienna for most of the gold standard period (1880-1913).

We use the interest-rate differential between Austrian silver and gold bonds to derive an *ex ante* market-based measure of inflation expectations. Our use of the silver-gold interest-rate differential is motivated by the observation that the gold-silver price ratio was a widely followed price reported daily by the financial press. Our empirical analysis suggests that inflation expectations were not a white noise process during the

gold standard period. We find economically meaningful persistence in inflation expectations at the weekly, monthly, and annual frequencies. Although we find that this measure cannot forecast realized inflation over the entire gold standard period, we do find evidence that our measure of inflation expectation can forecast the switch from gold deflation to gold inflation in the 1890s. As predicted by the Fisher equation, we also find that expected inflation was positively related to the level of nominal interest rates. Our measure of inflation expectations Granger-causes Austrian short-term interest rates as well as (paper) nominal interest rates. Using our unique measures of inflation expectations, we find evidence in favor of the operation of a short and long-run Fisher effect during the classical gold standard period.

We begin with a discussion of our data on Austrian bonds during the classical gold standard period. In Section III, we analyze the time series properties of inflation expectations during our sample period in Austria and then test for both short-run and long-run Fisher effects. The last section discusses our findings and their implications.

II. Austria and the Gold Standard

Some scholars have characterized nineteenth-century Austria as a financially underdeveloped, agriculturally-oriented economy, suggesting that it belonged to the periphery rather than to the core of European gold standard countries like the United Kingdom, France, or Germany. Although its GDP per capita was lower than the UK, Austria's standard of living compares favorably with France and Germany prior to the outbreak of World War I (see Figure 1). Austria was also one of the leading European

military powers of the late nineteenth century and its financial markets appear to have been well developed and integrated (Good, 1977). A well-developed network of joint stock banks with extensive branching networks (including the important Viennese banks) emerged in the 19th century to lend to businesses throughout the Austrian empire. Futher, Austria borrowed from the German model of universal banking in forming institutions such as the Creditanstalt fur Handel und Gewerbe (1855), and it created a central bank in 1816, modeled after the Bank of France, which had the exclusive right to issue notes.

As for exchange rate policy, Austria was a member of the silver standard for much of the nineteenth century. The Compromise of 1867 between Austria and Hungary gave constitutional foundations for a monetary union with the silver florin as the monetary standard and a central bank with no authority to print new currency issues. Despite this agreement, Austria and Hungary disagreed over the management of monetary policy. In addition to a monetary union, Hungary wanted overdraft facilities and a central bank office in Budapest. In July 1878, Austria and Hungary renewed the "Compromise of 1867" for ten years, but changed the name of the central bank from the Austrian National Bank to the Austro-Hungarian Bank. This new agreement created central bank offices in Budapest and Vienna with both German and Hungarian as the official languages of the monetary institution.

But after 1879, the florin was no longer convertible into silver. The exchange-rate system then began to resemble a float more than a peg. Silver florin traded for as much as seven percent from the mint par ratio and, as shown in Figure 2, exchange rates exhibited significant fluctuations in the 1880s. Austria then joined the gold standard in August 1892 after renewing the "Compromise" with Hungary for a second time. At this point, it

also established the kronen (crown) as its new currency. The kronen's value was fixed in terms of gold and complete control of the money supply was given to the central bank. The credibility of this new monetary regime was further buttressed in 1899 when Hungary was granted full parity with Austria in the management of the central bank. Investors reacted favorably to this new power-sharing arrangement: large capital inflows from the leading European financial centers including London, Paris, and Berlin occurred in response (Tullion and Wolters, 2007).

Flandreau and Komlos (2001) argue that even though Austria never formally established gold convertibility prior to World War I, the country was a *de facto* member of the gold standard by 1896 because of the stability of its exchange rate. For example, Tullio and Wolters (2007) show that the Austrian exchange rate vis-à-vis other major gold standard countries (England, France, and Germany) fluctuated within a range of about 15 percent between 1876 and 1891 and just eight percent between 1892 and 1895. The share of metallic-backed notes to paper notes issued by the central bank increased from an average of 53 percent over the period 1876-1895 to an average of nearly 75 percent over the period 1896-1914 (Tullio and Wolters, 2007). After 1896, the exchange rate for the Austrian crown relative to other gold standard countries fluctuated only two percent and +/- 0.4 percent from mint par (Flandreau and Komlos, 2001; Tullio and Wolters, 2007). Figure 2 confirms that Austrian exchange rates were remarkably stable after the country joined the gold standard. Based on the behavior of the exchange rate, Flandreau and Komlos (2001) conclude that Austria was a country that was neither a core nor a peripheral member of the gold standard, but rather somewhere in between.

Additional historical evidence from bond markets suggests that Austria may have more closely resembled a core gold standard country. In contrast to periphery countries, it successfully floated large amounts of government debt throughout Europe in its own currency. Issued in the late 1860s, the paper bonds were perpetuity obligations and subject to a 16 percent income tax. The coupon payments on the paper bonds were payable half-yearly on February or August 1st or on May 1st and November 1st (*Stock Exchange Official Intelligence,* various issues). The market value of unredeemed paper bonds exceeded more than 886 million Kroner in 1910. Morys (2008) finds that approximately 20 percent of the paper bonds were held by foreign investors.

Only the UK, France, Germany, Netherlands, and the United States were also able to sell large bond issues in their home currency on several European markets during the classical gold standard period. Austria suffered "original sin" only to the extent that its debt was denominated in gold, silver, and paper florin (Eichengreen and Hausmann, 1999; Bordo, Meissner, and Redish, 2005). A depreciation in the paper florin, for example, would require Austrian authorities to collect more tax revenues (in paper florin) to service its debt denominated in gold florin.[3]

Austria tapped international capital markets on a significant scale following the passage of the Law of March 16, 1876. The legislation authorized a 16 million florin bond issue that was exempt from Austrian taxes and paid interest half-year in gold in Vienna and other European exchanges including Amsterdam, Berlin, Brussels, Frankfurt, and Paris. Morys (2008) estimated that foreigners held approximately 80 percent of the debt issue. In 1910, the *Official Stock Exchange Intelligence* reported that there were

[3] This was true even after Austria joined the gold standard. As shown in the *Amsterdamsch Effectenblad,* after Austria joined the gold standard, the coupons for paper bonds often traded at a discount to the coupons for gold bonds.

more than 490 million Austrian Kroner gold bonds unredeemed that traded on markets throughout Europe.

Austria also issued silver bonds on the leading European exchanges. Like the paper bonds, the silver debt also did not contain a sinking-fund and had a five percent coupon. Issued in 1868, the bonds were perpetuity obligations and subject to a 16 percent income tax. The coupon payments on the paper bonds were payable half-yearly on February or August 1st or on May 1st and November 1st (*Stock Exchange Official Intelligence*, various issues). The silver debt had approximately 519 million Kroner outstanding in 1910.

III. Empirical Analysis

To derive a market-based measure of inflation expectations and to test for the presence of a Fisher effect during the gold standard period, we assembled a new database of weekly prices of Austrian gold, silver, and paper sovereign debt issues over the period 1880-1911.[4] Before carrying out our empirical analysis, we first describe how inflation expectations are calculated using these unique data.

A. Model

The Fisher equation states that the nominal interest rates on a given sovereign debt obligation is equal to the real interest rate plus the expected rate of inflation. The nominal interest rate for Austrian silver bonds can be written as:

[4] The *Economist* and *The Times* stopped quoting prices for Austrian paper bonds in 1911.

(1) $i_t^S = r_t + \pi_t^{e,S}$,

where r_t is the real interest rate and $\pi_t^{e,S}$ is the expected rate of silver inflation. The Fisher equation for Austrian gold bonds can be written as

(2) $i_t^G = r_t + \pi_t^{e,G}$.

Inflation expectations for the gold bond are denoted by $\pi_t^{e,G}$. The silver-gold interest-rate differential can be obtained by subtracting equation (2) from equation (1), which yields:

(3) $i_t^S - i_t^G = \pi_t^{e,S-G}$.

Equation (3) states that the silver-gold interest rate spread is equal to the expected rate of inflation in the silver-gold price ratio.

To carry out our empirical analysis, we make three assumptions about the bonds and investor behavior: (1) investors are risk-neutral; (2) the real interest rate is the same for both bonds given that the Austrian government issued the two debt obligations; and (3) silver and gold bonds have identical default risk. The third assumption of identical default risk appears reasonable since Austria faithfully repaid its sovereign debt during the entire gold standard period from 1880-1913. Given that the silver and gold bonds were widely held by foreign investors, Austria could not differentially default on the silver bonds without damaging its reputation in international capital markets. Even if there were some differential default risk between silver and gold bonds, the premium is not likely large enough to have a qualitative impact on our analysis.

Figure 3 plots current yields on a weekly basis for the Austrian gold, silver, and paper bonds from January 1880 to April 1911. The three series tend to move together, with the gold bond having the lowest interest rate over the course of the sample period. As shown in Table 1, the average interest rate for Austrian gold bonds during the gold

standard period is about 430 basis points with a standard deviation of 39 basis points. The interest rate on silver debt averaged approximately 555 basis points with a standard deviation of 61 basis points. Bond yields were highest during the silver standard for the two debt issues. Following the adoption of the gold standard, the average yield for the gold bonds fell by approximately 60 basis points and more than 100 basis points for the silver bonds. The average interest rate for paper bonds over the entire sample period was 559 basis points with a standard deviation of 63 basis points.

Figure 4 plots our imputed weekly measure of inflation expectations, $\pi_t^{e,S-G}$, alongside weekly current yields for Austrian paper-bonds for the period January 1880 to April 1911. The simple correlation coefficient between this nominal interest rate and inflation expectations is approximately 40 percent. Inflation expectations over the entire sample period averaged 1.25 percent (125) basis points and accounted for approximately 22 percent of the nominal interest rate (inflation expectations/nominal interest rate) under the assumption that the gold-silver price ratio is a reasonable proxy for general movements in the price level. Since inflation expectations were relatively stable (the standard deviation is less than three percent), the empirical evidence also indicates, as suggested by Siegel and Shiller (1977), that movements in real interest rates were probably more important than inflation expectations in driving fluctuations in Austrian nominal interest rates.

B. Persistence in Inflation Expectations

To examine the time-series properties of inflation expectations during the classical gold standard period, we first test for a unit root using the Augmented Dickey-

Fuller-GLS test. The null hypothesis of a unit root can be rejected at the one-percent level of significance.[5] We then estimate ARIMA models for the entire sample period as well as the periods when Austria was a member of the silver and gold standards to measure the persistence of inflation expectations. As shown in Table 2, inflation expectations in Austria are best characterized by an AR(3) process over the entire sample period. The sum of the autoregressive coefficients is over 97 percent, which indicates a high degree of persistence in inflation expectations. The constant indicates that investors expected inflation expectations of approximately 1.23 percent per year. For the silver standard period, we also find a high degree of persistence. Inflation expectations are best characterized by an AR(2) process. The sum of the autoregressive coefficients during the silver standard period is over 97 percent. The coefficient on the constant term in the equation suggests that financial market participants expected inflation to average approximately 1.51 percent per year.

For the gold standard period, we estimate ARIMA models from August 1892 to April 1911, and find that the best model for inflation expectations is an AR(2) model. Table 2 shows that the level of inflation persistence drops to about 94 percent. Although we observe a slightly lower level of persistence in inflation expectations after Austria joined the gold standard, there is a marked reduction in the average level of inflation expectations from 1.51 percent to 1.06 percent. These findings suggest that there was significant persistence in inflation expectations and that joining gold reduced the average level of inflation expectations by roughly 30 percent.

[5] We experimented with lag lengths of 1 to 12 for the unit root tests. In all cases, we were able to reject the null hypothesis of a unit root at the five percent level of significance.

One potential problem with our analysis is that the large persistence in inflation expectations is simply driven by using high frequency data. To consider this possibility, we re-estimated the baseline empirical results using end-of-month data. The ARIMA models of monthly inflation expectations are presented in Table 3. The results are similar to those employing the weekly data. Inflation expectations followed an AR(1) process when the country adhered to the silver standard and inflation persistence is greater than 90 percent and significant at the one-percent level. For the gold standard period, inflation expectations are best modeled as an AR(1) process. Although inflation expectations are once again not a white noise process, the coefficient on the autoregressive term falls by roughly 13 percent, from 95 to 83 percent.

Using annual data, we find similar results for the persistence of inflation. The constant term shown in Table 4 indicates that annual inflation expectations averaged more than one percent over the full sample period. Again, we find that there is significant persistence in inflation expectations: the sum of the two autoregressive terms is nearly 90 percent. Hence, using weekly, monthly, or annual data, we find substantial persistence in inflation expectations during the gold standard period as measured by the silver-gold interest rate differential.

One possible critique of our analysis is that Austria's commitment to gold might have been perceived as less credible than other western European countries, and hence the analysis of inflation expectations we derive for it may not be very representative of gold club members. That is, inflation expectations for non-credible members of the gold standard may be much larger than for countries that strictly adhered to the monetary rule. While Austria was a newer member of the gold standard in comparison to France,

Germany, and the UK, it does not appear that market participants viewed its commitment to gold as substantially less credible than these countries. Mitchener and Weidenmier (2008) provide evidence that Austria was one of the most credible gold standard monetary regimes during the period 1870-1913: market participants expected the Austrian kroner to depreciate approximately three percent after the country joined the gold standard based on the premium of paper over gold bonds. The level of expected depreciation is considerably smaller than several other gold standard countries including the United States, Argentina, Brazil, Chile, India, Mexico, and Russia. We therefore interpret our results as providing a lower bound on the size and persistence of inflation expectations for the average country during the classical gold standard period.

C. Forecasting Inflation

The presence of significant persistence in inflation expectations suggests that the interest-rate differential between paper and gold bonds might be able to predict future inflation rates during the gold standard. One problem with testing this hypothesis during the gold standard is that price indices from this period do not always provide useful information. Governments did not regularly collect information on the goods and services people purchased on a monthly basis (Perez and Siegler, 2003; Hanes, 1999).[6] This makes it difficult to construct reliable consumer price indices that can be compared to a general measure of inflation expectations imputed from financial markets. A possible solution for dealing with the paucity of price data is to examine the interest-rate

[6] Hanes (1999) constructed a consistent consumer price index series for the United States from 1870-1990. For the gold standard period, he constructs a consumer price index based on 1911 survey from the United States Bureau of the Census.

differential between Austrian gold and silver bonds. This yield spread should reflect inflation expectations regarding the gold-silver price ratio, a relative price that was widely followed by investors and reported by the major financial newspapers during the classical gold standard era. The monthly gold-silver price ratio, shown in Figure 5, sharply declines in the first part of the sample period and then fluctuates up and down from about 1894 until April 1911. The gold-silver interest-rate differential, our measure of inflation expectations, also appears in Figure 5. The simple correlation coefficient between the two price series is approximately zero, which suggests that the contemporaneous correlation between the two series is not very strong.

It is nevertheless possible that lagged values of our measure of inflation expectations might be able to predict gold-silver inflation. To test this hypothesis, we first examined the gold-silver price ratio for a unit root using the Augmented Dickey-Fuller-GLS test. The null hypothesis of a unit root could easily be rejected at the one-percent level of significance.[7] We then ran a series of Granger-causality tests to test if inflation expectations imputed from the silver-gold interest rate differential can predict movements in changes in the gold-silver price ratio. We estimated VARs with lags lengths of one to six for the entire sample period as well as the periods when Austria was a member of the gold and silver standard. For the whole sample period, we do not find evidence that inflation expectations Granger-cause gold-silver inflation (table 5). The same is true for the sample period when Austria was a member of the silver standard. For the gold standard period, inflation expectations do not Granger-cause gold-silver inflation over the period August 1892-April 1911. However, we do find strong evidence that inflation expectations Granger-cause gold-silver inflation from August 1892-1903 as well as for

[7] The test statistics for Augmented Dicker-Fuller test was nearly -15 with a p-value of 0.00.

sub-periods within this timeframe. This suggests that market participants forecasted part of the switch from gold-deflation to inflation in the 1890s. Once the gold-silver price ratio stabilized in the early 1900s (with realized inflation not statistically different from zero), inflation expectations were not very useful in forecasting realized inflation. One explanation for this result is that realized gold-silver inflation was essentially a white-noise process by the early 1900s.

D. Fisher Effects

To test for the presence of a short-run Fisher Effect, we analyze the relationship between the Vienna Open market interest rate and our measure of inflation expectations.[8] The Vienna open market rate is the most important short-term money market rate used to conduct trade with other countries. The Austrian short-term rate along with the silver-gold interest rate spread is shown in Figure 6. To analyze the relationship between short-term interest rates and inflation expectations in more detail, we estimate a series of Granger-causality tests. We first test the short-term interest rate series for a unit root using the Augmented Dickey-Fuller-GLS test. We can easily reject the null hypothesis of a unit root at the one-percent level of significance.[9] As shown in Figure 6, the short-term open market rate appears to be mean reverting for Austria. We then estimate Granger-causality tests with one to six lags for the entire sample period as well as the periods when Austria was a member of the silver standard (January 1880-July 1888) and gold standard (August 1892-April 1903). As shown in Table 6, for the entire sample period,

[8] For studies examining the Fisher effect using modern data, see Mishkin (1981, 1992) and Fama (1975).
[9] The fact that the null hypothesis of a unit root can easily be rejected for the short-term interest rate series shows that there is not a structural break in the time series.

we find strong evidence of the operation of a Fisher effect. The inflation expectations measure (based on the gold-silver price ratio) Granger-causes short-term interest rates in a VAR with three, four, five and six lags. We find similar results for the gold standard period. The only exception is the silver standard period. One possible explanation for the absence of Granger-causality during the silver standard period is that we have included the period of reforms when Austria moved from a silver standard to a gold standard. To consider whether our results are sensitive to including the reform period, we re-estimated the Granger-causality tests for the period 1880-1887. In this restricted sample period when Austria was on silver, we find much stronger evidence of Granger-causality. Gold-silver inflation expectations Granger-cause short-term interest rates at the five-percent level in VARs with six, seven, eight, or nine lags. Overall, we interpret the results as strong evidence of a short-run Fisher effect during the classical gold standard period.

Using Austrian paper bonds, we next test for the presence of a long-run Fisher effect. The current yield on the paper bond should provide some insight into whether there was a relationship between nominal interest rates and expected inflation measured as the interest rate differential between silver and gold bonds. Figure 7 shows inflation expectations along with the silver currency bonds for the period 1880-April 1911. The two series move together over the entire sample period, suggesting a strong positive link between nominal interest rates and expected inflation. The simple correlation coefficient between the two time series is 40 percent.

We examine the relationship between Austrian inflation expectations and the interest rate on paper bonds using Granger-causality tests. We first test the time series of paper interest rates for a unit root using the Augmented Dickey-Fuller test. The null

hypothesis of a unit root can be rejected using either a constant or constant and trend in the model. Then we run Granger-causality tests over the three sample periods used in the earlier analyses. For the entire sample period, we find evidence that inflation expectations Granger-cause movements in Austrian (paper) interest rates in VARs with lag lengths of three, four, five, and six lags. We also find evidence of Granger-causality during the period when Austria was on the silver standard. The only exception is during the gold standard. The lack of Granger-causality appears to be explained by the high degree of contemporaneous correlation of the residuals between the two variables in a two-variable VAR. Indeed, shocks to inflation expectations can explain almost the entire forecast error variance in paper interest rates as long as inflation expectations are given the first ordering in the Choleski decomposition. Otherwise, innovations in the paper interest rates explain almost all of the movements in paper interest rates. We interpret this evidence that the two series are co-determined. Although we cannot separate to what extent contemporaneous shocks to inflation expectations impact paper interest rates, there is clearly a relationship. Again, we interpret this result as evidence of the operation of a long-run Fisher effect during the gold standard period.

V. Conclusions

Macroeconomists and economic historians have long searched for the operation of Irving Fisher's eponymous effect during the classical gold standard period. We show that Fisher and his effect may be lurking in the inflation expectations of Austrian sovereign debt issues of the 19th century. We compute one of the first, high-frequency market-based

measures of general inflation expectations for the classical gold standard period so that we can test for the presence of the Fisher effect. Previous studies have used gold bonds and econometric models to examine the relationship between nominal interest rates and inflation. We believe that our measure, the interest rate differential between silver and gold bonds, provides a more direct approach for studying the behavior of inflation expectations during the gold standard period and its relation to actual inflation. Our measure is motivated by the fact that the gold-silver price ratio was widely followed by contemporary market participants and the fact that our measure of inflation expectations does not rely on modern econometric tools and software to calculate.

Our analysis of inflation expectations, proxied by the interest rate differential between silver and gold bonds, suggests several conclusions. First, the adoption of the gold standard reduced the average level of inflation expectations in Austria. Joining the gold standard led to a 30 percent drop in inflation expectations, from 1.5 percent to 1.1 percent, as measured by decisions made in financial markets. We also find that there is considerable persistence in inflation expectations of the gold-silver price ratio at the weekly, monthly, and annual frequencies. As shown by our analysis of the gold-silver price ratio, market participants clearly predicted a significant portion of gold deflation and gold inflation as well as the switch from a declining price level to an increasing price level in the mid-1890s. Finally, we find evidence of short-run and long-run Fisher effects. Inflation expectations Granger-cause movements in short-run and long-run nominal interest rates. Market participants during the classical gold standard period required an inflation premium that was built into nominal interest rates as long as the debt obligation was denominated in silver or paper rather than gold.

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Table 1. Mean Austrian Interest Rates, 1880-April 1911 (Basis Points)

	Whole Period (Std. Deviation)	Gold Standard (Std. Deviation)	Silver Standard (Std. Deviation)
Gold	430.134 (38.572)	405.53 (10.064)	466.767 (36.168)
Silver	555.108 (61.265)	511.581 (13.015)	619.903 (45.470)
Paper	559.887 (63.685)	515.010 (13.224)	626.691 (48.681)

Table 2. ARIMA Models of Inflation Expectations(Weekly Data)

	Whole Period	Silver Standard	Gold Standard
Constant	123.15*** (11.300)	151.14*** (12.393)	106.019*** (1.689)
AR(1)	0.791*** (0.025)	0.772*** (0.038)	0.855*** (0.032)
AR(2)	0.141*** (0.031)	0.206*** (0.038)	0.084*** (0.032)
AR(3)	0.057** (0.025)		
Observations	1631	655	976

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. ARIMA Models of Inflation Expectations (Monthly Data)

	Whole Period	Silver Standard	Gold Standard
Constant	122.765*** (12.809)	149.879*** (15.430)	106.075*** (1.92)
AR(1)	0.971*** (0.012)	0.948*** (0.028)	0.830*** (0.037)
AR(2)			
AR(3)			
Observations	375	149	225

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. ARIMA Models of Inflation Expectations
(Annual Data)

	Whole Period
Constant	122.576*** (14.257)
AR(1)	1.485*** (0.153)
AR(2)	0.608*** (0.154)
Observations	30

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5
Forecasting the Gold-Silver Price Ratio
Granger-Causality Tests (F-tests)

Lags	Whole Period	Silver Standard	Gold Standard
1	0.401	0.401	0.032
2	0.200	0.201	0.399
3	0.221	0.210	0.509
4	0.179	0.172	1.351
5	0.150	0.141	1.242
6	0.207	0.192	1.586

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6
Short-Term Fisher Effect
Granger-Causality Tests (F-tests)

Lags	Whole Period	Silver Standard	Gold Standard
1	0.747	1.823	0.412
2	1.304	0.862	5.684***
3	3.637**	1.328	6.070***
4	4.173***	1.876	5.216***
5	3.418***	1.563	4.189***
6	3.489***	1.853*	3.407***

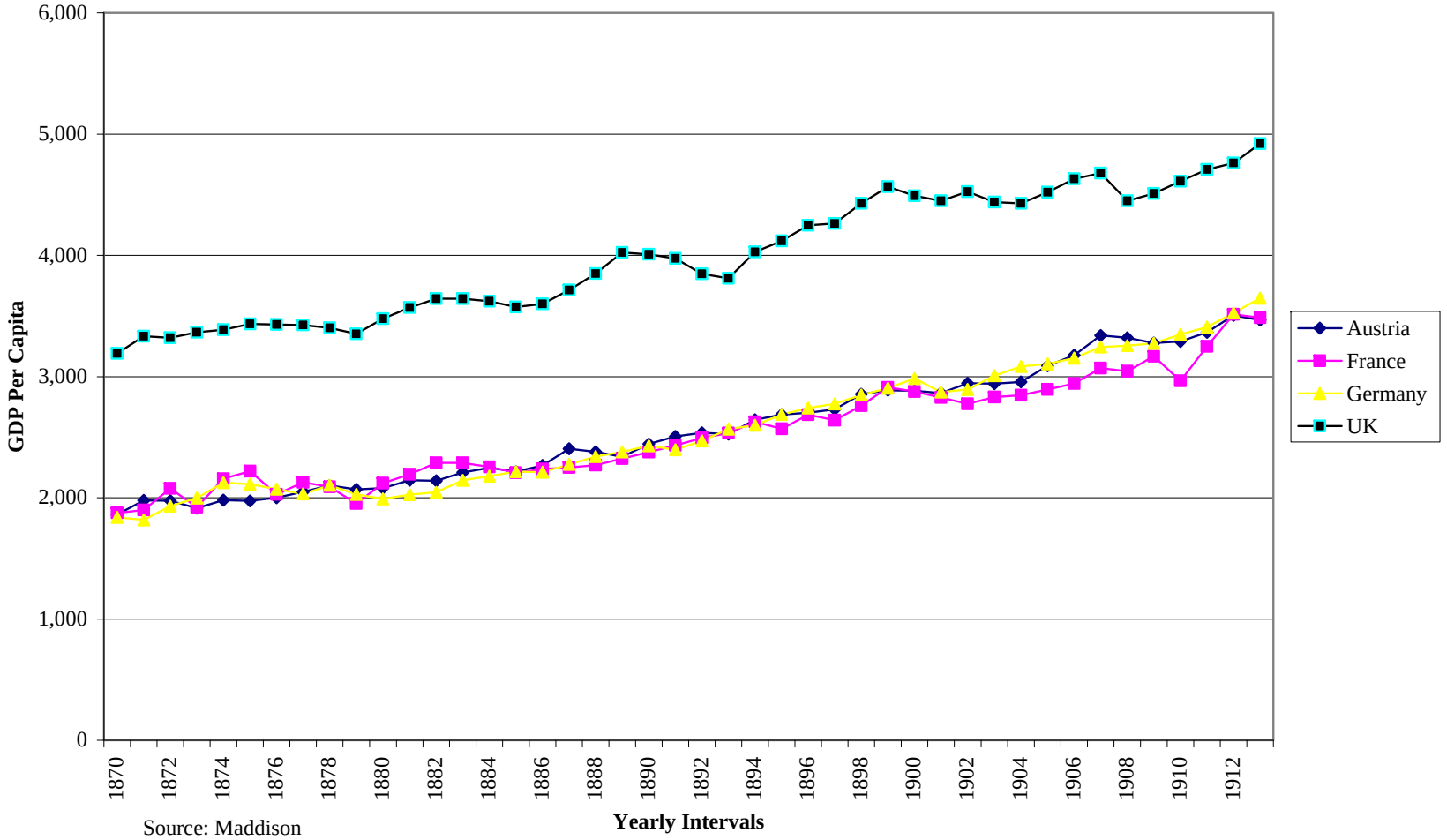
*significant at 10%; ** significant at 5%; *** significant at 1%

Table 7
Long-Term Fisher Effect
Granger-Causality Tests (F-tests)

Lags	Whole Period	Silver Standard	Gold Standard
1	0.215	0.335	0.168
2	1.881	1.184	0.076
3	2.115*	1.335	0.142
4	2.207*	1.500	0.112
5	2.677**	2.445**	1.219
6	4.344***	3.792***	1.018

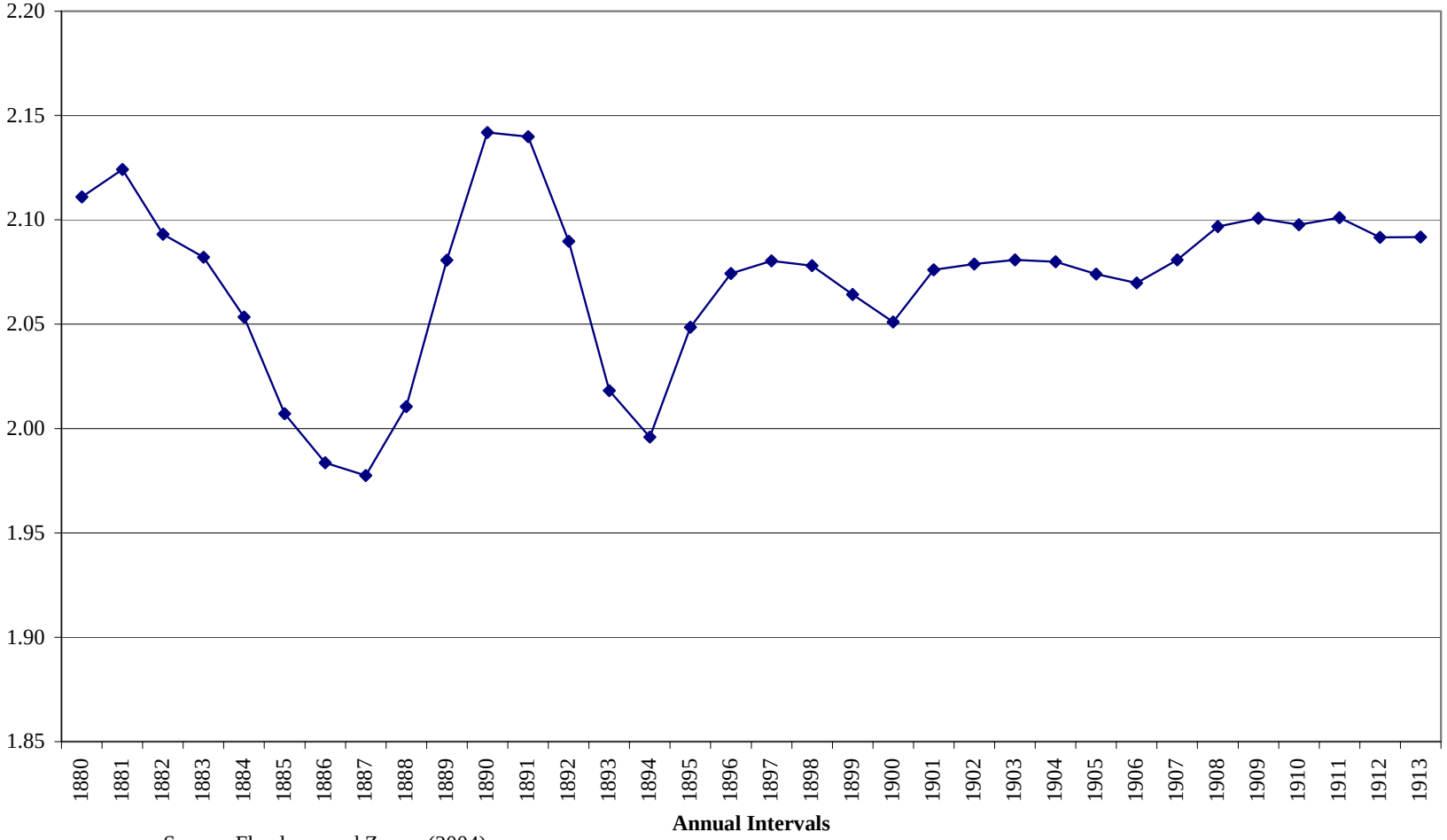
*significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1
GDP Per Capita, 1870-1913



Source: Maddison

Figure 2
Franco-Austrian Exchange Rate 1880-1913



Source: Flandreau and Zumer (2004)

Figure 3
Austrian Gold, Silver, and Paper Bonds, 1880-April 1911
(Basis Points)

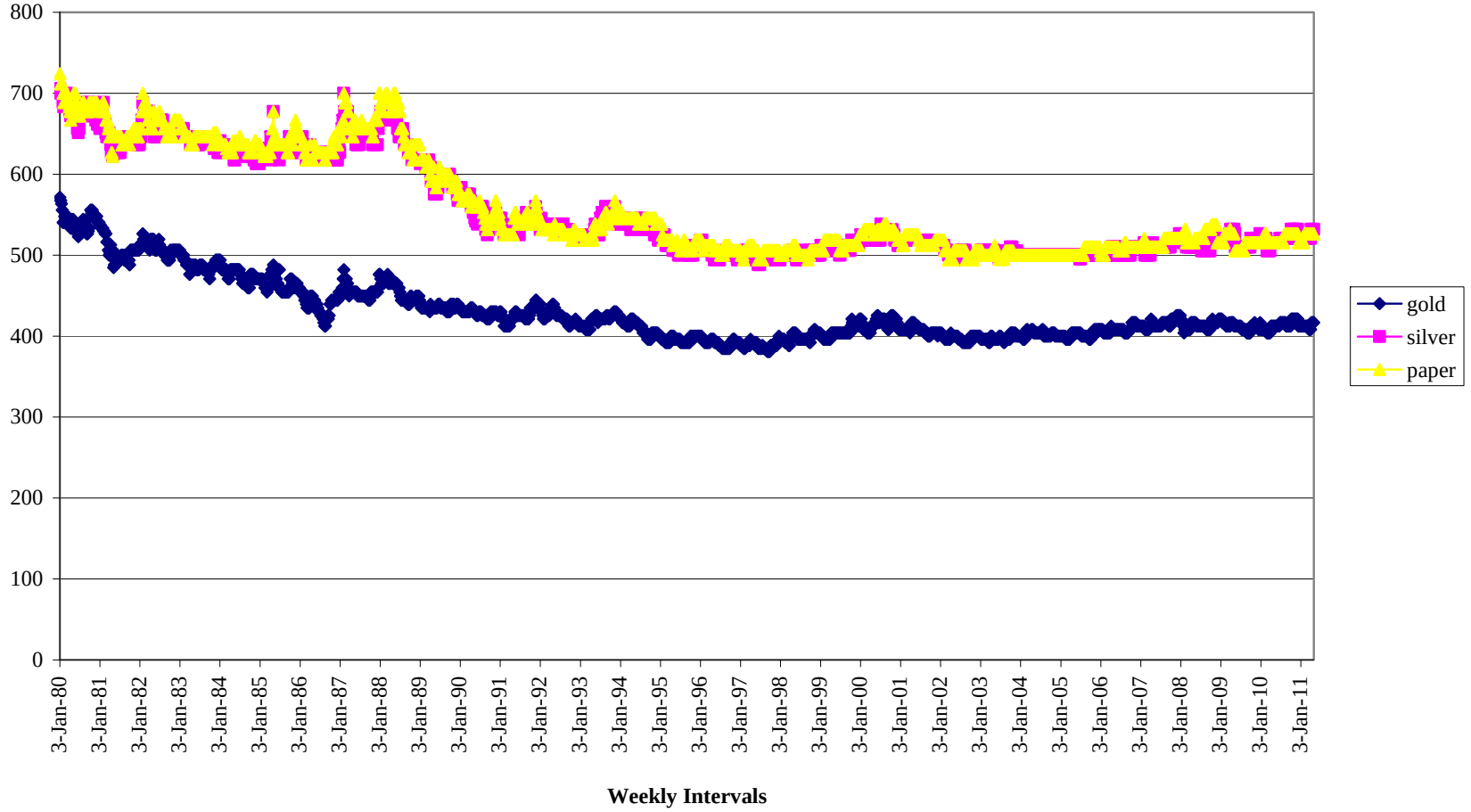


Figure 4
Austrian Inflation Expectations and Nominal (Paper) Interest Rates, 1880-April 1911
(Basis Points)

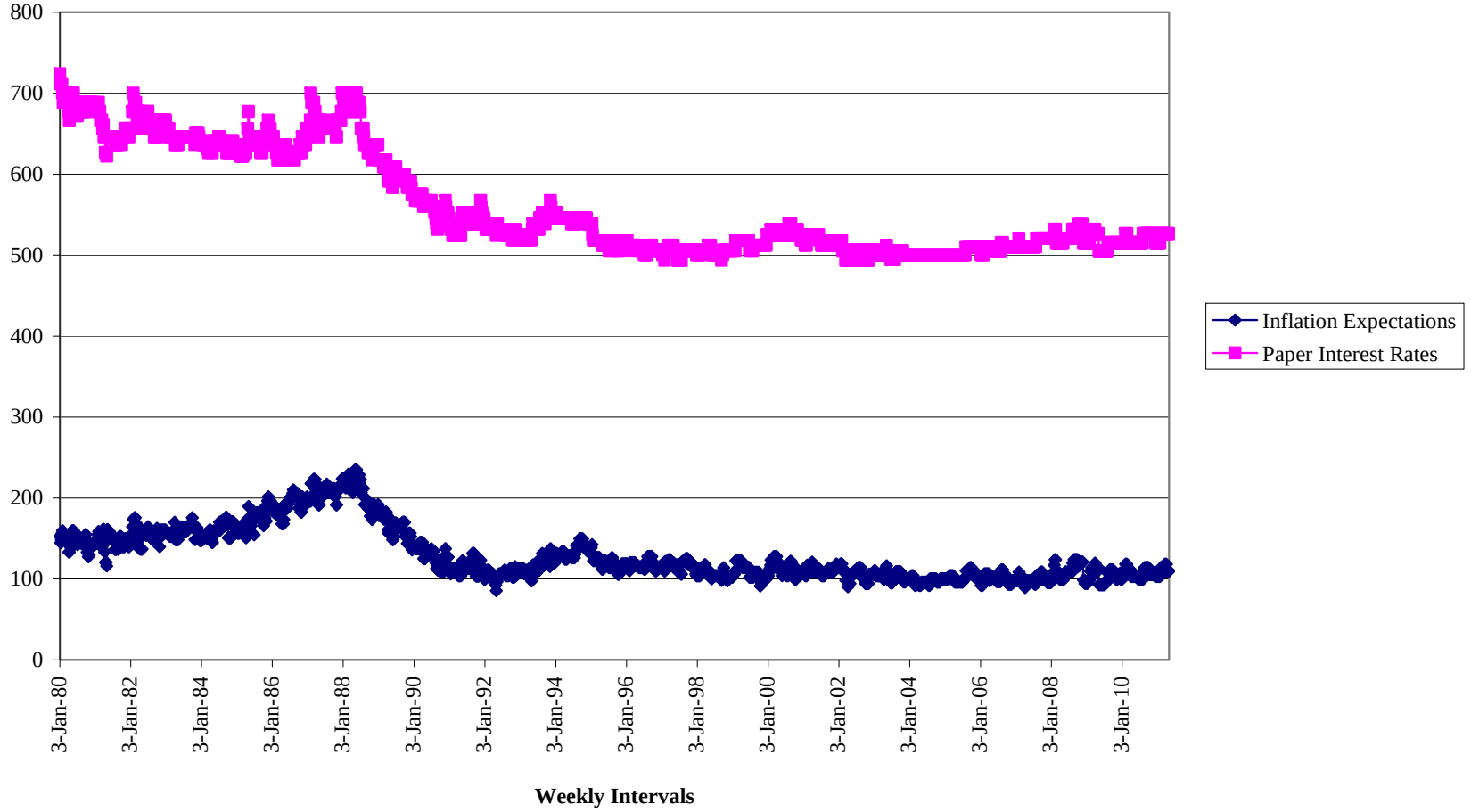


Figure 5
Inflation Expectations and Gold-Silver Price Inflation

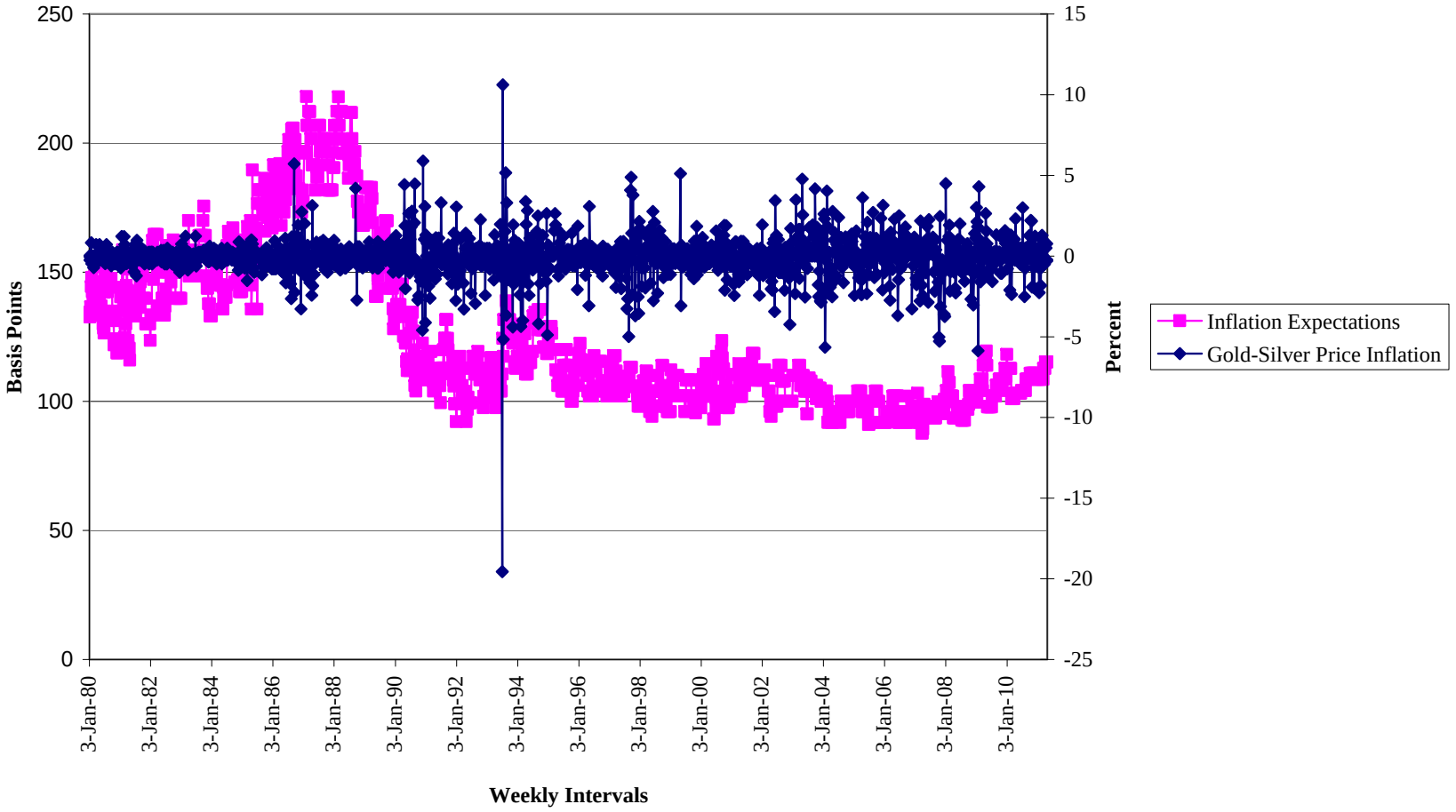


Figure 6
Short-Term Interest Rates and Inflation Expectations, 1880-April 1911
(Basis Points)

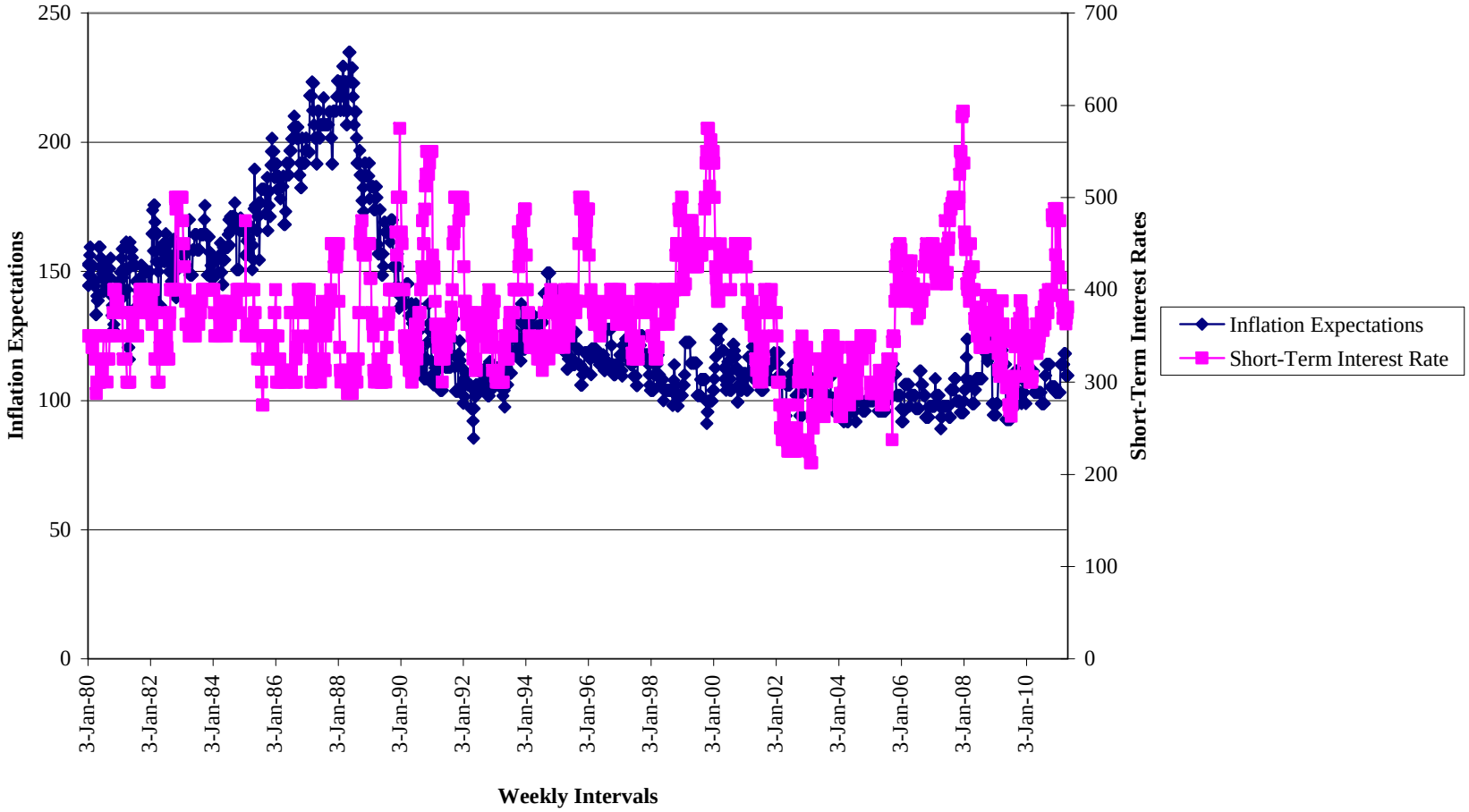


Figure 7
Inflation Expectations and Paper Interest Rates, 1880-April 1911
(Basis Points)