

Predictability of future economic growth and the credibility of different monetary regimes in Germany, 1870 - 2003

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A regime with a high persistence of inflation and, hence, low credibility exhibits a high level of predictability of economic growth using the yield curve as indicator. Our study tries to quantify the degree of anticipation of economic growth and links this to the capability of regimes to fight against inflation. We focus on Germany and collect data from 1870 to 2003. The period of the Classical Gold Standard exhibited the highest credibility compared to the interwar period, the Bretton Woods and free float era. The reliability of the Bretton Woods agreement deteriorated years before the official break down in 1971.

JEL codes: N13, N14, E27, E43

Keywords: credibility, term structure, yield curve

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1. Introduction

During recessions, market participants try to avoid engaging in long-term contracts like long-term bonds. Hence, these bonds exhibit high risk premia: current prices are low and hence expected yields are high. In that sense, bond yields increase in the presence of an economic slowdown; consequently, they react countercyclical. In contrast, short-term rates show a procyclical behavior in that they decline during recessions. As Ang, Piazzesi, and Wei (2004) pointed out, this procyclical pattern might be driven by the central bank that lowers short-term rates to stimulate economic growth. Yet one could also refer to the fact that market participants favor short-term engagements during insecure economic times. This shift in demand towards short-term securities reduces short-term interest rates. Accordingly, recessions are characterized by an upward-sloping yield curve and hence by a positive spread, which is defined as the difference between long and short-term interest rates. Due to the fact that economic activities follow a cyclical behavior, namely an alternation between recessions and booms, a high spread indicates a future recovery of the economy. Based on this consideration, a couple of studies related spread to future economic growth and used standard OLS procedures for estimating forecasting models (see among others Harvey, 1989, 1993; Laurent, 1988; Stock and Watson, 1989; Chen, 1991). Besides standard OLS regressions, Estrella and Hardouvelis (1991) and Estrella and Mishkin (1998) tried to predict recessions coded as ones applying a binary choice model. Generally, predicting future growth rates is quite successful despite concerns regarding the stability of the used models (see Stock and Watson, 2001). Yet these studies covered relatively short periods; hence, considerable regime shifts were usually not included. Our paper, contrarily, focuses on major regime changes from 1870 to 2003 that occurred in Germany. We try to evaluate the impact

of these regime shifts on the predictability of future economic growth rates. Furthermore, the predictability of future growth is linked to the credibility of the respective monetary regime. This is motivated by the paper due to Bordo and Haubrich (2004) that analyzed the predictability of future growth over the period 1875 to 1997 for the U.S. economy. Tackling the data problems inherent when working on German economic history, we try to conduct a similar study for Germany. Obviously, changes of monetary regimes over time in Germany make our study promising, as one can uncover whether the degree of credibility of monetary policies could affect the predictability of future growth. Bordo and Haubrich (2004) argued that regimes with lower reliability and, hence, high persistence of inflation exhibited better predictability compared to other regimes. In addition, Peel and Ioannidis (2003) emphasized that the coefficient becomes smaller and hence the impact of the yield curve becomes less intense if policy makers focus more on preventing inflation. They referred to an output forecasting regression with the yield curve as explanatory variable. Accordingly, there seems to be a linkage between credibility of monetary regimes and the predictive of spreads regarding future economic growth.

Based on the work of Mitchell (1913) and Kessel (1965), one can identify the yield curve and hence spreads as good predictors for future growth. Studies for the U.S. showed that inversions, which are periods of higher short than long-term interest rates, worked as a good indicator for recessions. Studies concerning the predictability of macroeconomic variables for historical periods in Germany are rare. An exception is Voth (1998) who conducted a study on the predictability of inflation rates for Germany. In contrast to his study that concentrated on the 1930s and on inflation expectations, we want to cover a long time horizon and analyze different monetary regimes. Moreover, we try to infer the predictability of future economic growth rates.

To model the expectations regarding future economic growth, we apply several methods, namely ARIMA specifications with and without spreads as explanatory variable and VAR models. The ARIMA models without spreads represent a reference group for the more elaborate model that include spreads as indicators for future growth. Based on our previous findings for the period of the Classical Gold Standard, one should expect that under stable conditions with regard to price stability, the predictability should be very low (see Baltzer and Kling, 2004). However, there is little known for the period after 1914; hence, it seems to be worthwhile to extend our analysis in order to cover a variety of monetary regimes.

We use similar data sources as described by Voth (1998), namely the private discount rate as a measure for the short-term interest rate and an index of bond yields for the long-term counterpart. With these measures, we can derive the yield curve for Germany and test whether based on this information the quality of predictions outperform a simple ARIMA process. Related to searching for reliable data is the question whether one follows Hoffmann (1965) or Burhop and Wolff (2005) regarding GDP estimates for the pre-1914 period. Measuring economic growth for this period is a current debate, and one has to decide among different possible time series of net national product that were reconstructed. To overcome this problem, we use the 'traditional' Hoffmann (1965) as well as the recalculated Burhop and Wolff (2005) time series. Maybe, our research can also contribute to this debate in that we investigate which time series is easier to predict.

Our paper is organized as follows: first, section two highlights former theoretical and empirical contributions concerning the interrelation between spreads and future economic growth; second, the various data sources are thoroughly discussed; third, we explain the steps of our empirical analyses and close with

concluding remarks to stress our main findings. Our results confirm Bordo and Haubrich's (2004) results and add some evidence with regard to regime changes in Germany to the body of U.S. oriented literature.

2. Former theoretical and empirical research

2.1. The impact of the yield curve on economic growth: Empirics and theory

Why should one expect a theoretically justified impact of the spread - defined as the difference between nominal long and nominal short-term interest rates - on economic growth? Despite the large body of empirical literature that documented the excellent leading indicator properties of spreads, theoretical justifications are more difficult to find.

Mitchell (1913) marked the beginning of the empirical literature, as he was one of the first who discovered different patterns in long and short-term interest rates in the U.S. economy. More elaborate empirical studies for the U.S. followed and showed that inversions – short-term rates exceed long-term interest rates – predict recessions (see Estrella and Hardouvelis, 1991), and, more generally, a steep yield curve predicts fast and a flat curve slow future economic growth (see Harvey, 1988, 1991; Haubrich and Dombrosky, 1995).

Thus far, there is no formal economic model capable explaining why the yield curve might predict economic growth.¹ Nevertheless, spreads contain lots of information on a number of economic variables. Consider that spreads represent the difference between nominal interest rates on bonds of different maturity; hence, they are composed of the real term spread, which is the expected difference in inflation, and the term premium. Note that only temporary changes in inflation or real interest

¹ We refer to Dotsey (1998).

rates affect the spread, as a permanent increase in either inflation or the real interest rate has the same effect on long- and short-term interest rates and hence the spread remains unchanged.

What leads the yield curve to an inversion? Let us assume an increase in expected inflation, which is reflected in the slope of the yield curve. Consequently, the central bank – if the regime wants to be credible – should draw in the reins by rising short-term interest rates. Even if the long-term interest rates initially rise as well, long-term rates usually lag behind and, thus, the spread narrows. In the following, the long-term rates often fall because inflationary expectations subside, and, consequently, the yield curve could invert. This inversion indicates an imminent recession.

Beyond this explanation, Plosser and Rouwenhorst (1994) noted that the spread's behavior is consistent with real business cycle theory. In a real business cycle model, relatively high-expected future growth would imply rising real interest rates and an increase of the slope of the yield curve. The converse would occur if growth rates were expected to slow. Accordingly, the spread could signal expected changes in the economy that are due to nonmonetary shocks.

2.2. Interrelation between the yield curve and monetary regimes

Despite the fact that an increasing amount of studies analyzed the predictability of future economic growth using spreads for other countries than the U.S. (e.g. Harvey, 1989; Stock and Watson, 2001; Gonzalez, Spencer, and Walz, 2000), these studies left an essential question behind. Can differences regarding the predictability of future growth rates be explained by the dependence on the respective monetary regime? As nearly all studies focused on the post-World War II period, the empirical findings

might be biased by the fact that special circumstances existed with respect to the structure of the economy, financial markets, and monetary policies. Motivated by the paper due to Bordo and Haubrich (2004) that focused on the question to which extent the predictive ability of the yield curve in the U.S. was related to the monetary regime in place, we try to follow this question for Germany. Obviously, observing changes of monetary regimes over time adds additional evidence on the interrelation between predictability and credibility of regimes.

Gamber (1996) stressed an additional point overlooked by Bordo and Haubrich (2004), namely the linkages between spreads and concrete monetary policies like setting short-term interest rates. Using empirical tests, we try to uncover whether spreads directly affect future economic growth, or spreads trigger a change in short-term interest rates set by the central bank that in turn influence economic recovery. This empirical tests focuses on the Classical Gold Standard, as spreads seem to be completely irrelevant for future economic growth. By analyzing the relation between spreads and the discount rates determined by the 'Reichsbank', we could find explanations for our finding.

2.3. Credibility of monetary regimes and predictability of future economic growth

Within a subsequent section, we test two hypotheses for the Classical Gold Standard, namely that inflation shocks and real economic shocks influence short-term rates – but long-term rates remain unchanged. After testing these hypotheses mentioned by Bordo and Haubrich (2004) for the era of the Classical Gold Standard in Germany, one can state the following: as a change in inflation rates as well as a real economic shock affect the short-term interest rates and leave the long-term yield unchanged, both shocks have similar impacts. The spread reacts in a similar manner if inflation

changes or real shocks occur. Observing changes in the spread do not allow precise predictions regarding future economic growth rates because changes of spreads can be due to two different and undistinguishable sources. Spreads are a noisy signal. Based on this argumentation, one can state that a monetary regime with high credibility should exhibit a low predictability of future economic growth using spreads as explanatory variables. In contrast, an incredible regime in which the inflation follows a random walk and hence is highly persistent should permit a high predictability.² Note that under such a regime, an inflation shock also influences the long-term expectations and thus long-term rates. Contrary, real economic shocks are still limited to the impact on short-term rates. Changes of the spread can be regarded as clear signal for future economic growth rates. Based on these considerations, measuring the predictability can be regarded as a proxy of the reliability of a monetary regime. Hence, we try to quantify the credibility of regimes in Germany over time.

3. Data

As the period we want to cover is remarkably huge, various data sources have to be combined to construct the spread and economic growth rates. Table 1 provides an overview regarding the data sources. For the pre-1914 period, Hoffmann (1965) provided economic growth rates that have discussible weak points in constructing the data for the 1870s (see Fremdling, 1991; Burhop and Wolf, 2005). To overcome this reliability issue, we use the ‘traditional’ Hoffmann (1965) as well as the recalculated Burhop and Wolff (2005) time series. Following Voth (1998), private discount rates serve as a proxy for short-term interest rates and the average yield achieved on the bond market is a measure for the long-term level of interest rates. Donner (1936)

² See Evans and Wachtel (1993).

collected the series of interest rates for the pre-World War I period. From 1950 to 1959, we do not have data for the private discount and instead take the rate of day-to-day money obtained from Morawietz (1994). Note that private discount rates and the day-to-day money rates are highly correlated during the years when both data series existed (see Morawietz, 1994). The rest of the data for the pre-1975 period can be found in 'Deutsches Geld- und Bankwesen in Zahlen 1876-1975' edited by the 'Deutsche Bundesbank'.

For the period after 1975, we rely on time series data provided by the 'Deutsche Bundesbank' and the 'Statistische Bundesamt'. As there are from that date on interest rates of three-months treasury bonds and of ten-year 'Bundesanleihe' available, we switch to these proxies for short- and long-term interest rates. These proxies meet the standards of comparable studies nowadays. To assess whether our new proxies are comparable to our estimates for the preceding period, we use the period from 1967 to 1974, during which all four time series are available, to obtain empirical evidence. Figure 1 plots for this overlapping period all four measures for short and long-term interest rates. Generally, the development of these measures is highly parallel. However, the private discount is always below the three-months treasury bond; hence, the spread before 1975 should have a higher level due to the difference in proxies. Despite this fact, the number of inversions is considerably higher before 1975 than afterwards. This number is especially high during the Classical Gold Standard era as discussed in a subsequent section. Thus, we can state that the proxies deliver a precise estimation for spreads. To obtain an overview regarding our database, figure 2 plots spreads and economic growth rates for the period from 1870 to 2003.

4. Empirical model

4.1. Descriptive analysis: Inversions during the Classical Gold Standard

Figure 3 exemplarily depicts for the period of the Classical Gold Standard spreads and economic growth rates. One observes inversions, which seem to predict recessions pretty well during this period. The first inversion occurred in 1890 and was followed in 1891 by a severe economic decline of about 5.48%. A less severe inversion happened in 1898 and predicted a pronounced drop in growth rates from about 7.92% to 0.24%. 1899 and 1900 also exhibited inversions and the growth rate reached -0.86% and -2.44% in 1900 and 1901, respectively. The inversion in 1906 was misleading – but 1907 showed an even stronger negative difference between short-term and long-term interest rates; thereafter, a recession took place. Interestingly, shortly before the First World War, inversions in 1912 and 1913 indicated a slowdown in the economy. Accordingly, the high number of inversions during the pre World War I period is astonishing compared to later periods (see figure 2). Motivated by this descriptive impression, our empirical models should consider the alleged predictive power of inversions.

4.2. Standard regression model for different monetary regimes

Besides descriptive evidence that spreads and – as described in the previous section – inversions seem to be a reliable indicator for forthcoming recessions; we want to estimate the following standard regression model. Contrary to Bordo and Haubrich's (2004) study for the U.S., we cannot work with quarterly data. Our model takes the following form; hereby, the frequency of the data is annual.

$$\Delta y_t = \alpha + \beta(L)spread_t + \gamma(L)\Delta y_t + \varepsilon_t \quad (1)$$

In contrast to former studies, we also allow for an arbitrary lag structure for the spread and not just for the autoregressive terms. However, included the spread of the previous year is enough to capture the interrelations.³ To obtain a good specification for this model, we propose to inspect the partial autocorrelation function (PACF) of the growth rates. This gives us a clue about the lag structure for the autoregressive component. Based on the PACF plot, one could skip autoregressive components. In the literature based on quarterly data, four lags are common. Hence, we propose to try an AR(1) specification and test whether this term increases the explanatory power considerably. Information criteria can support the search for an appropriate specification.

Our descriptive finding stresses that inversions seem to predict recessions pretty well. Hence, we reconsider the standard regression model by inserting an indicator variable labeled I that takes the value one if an inversion occurs.

$$\Delta y_t = \alpha + \beta(L)spread_t + \chi(L)I_t + \gamma(L)\Delta y_t + \varepsilon_t \quad (2)$$

Moreover, let's permit an arbitrary lag structure for the inversion and determine the lags by inspecting a cross-correlogram.⁴ Inversions play an important role about one year prior to declines in growth rates; thus, we try a specification with one lag. We carry out this extended model for the Classical Gold Standard era, the interwar, the Bretton Woods and the free-float period. Table 2 reports our empirical results.

Our analysis uncovered that inversions can predict a drop in growth rates, albeit spreads do not possess any forecasting power. Therefore, one can conclude that only extreme events like inversions serve as a reliable indicator for recessions in the

³ This can be conformed by inspecting cross-correlograms or regressing the basic model with different numbers of lags and comparing the models by calculating information criteria like Akaike or Schwarz.

⁴ We use the cross-correlation between inversions and economic growth rates.

pre-1914 period. This finding differs from Bordo and Haubrich (2004), as they did not carry out a model that incorporates inversions as indicator variables. Yet this evidence is rather weak due to the p-value exceeding slightly the 5% level of significance. Regardless how unreliable the respective monetary regime was, the explanatory power of the model and hence the predictability stays low. The linkage between predictability of future growth rates and credibility of monetary regimes seems to be disputable. Two shortcomings could be responsible for the low predictability of the standard regression. First, the number of observations is depending on the respective period low – but increasing the frequency of data is not possible for the period before 1975. Second, the empirical model might be misleading in that the spread affects growth rates but not vice versa. The following section tackles the latter issue by permitting such feedback effects; thereby, a vector autoregressive (VAR) model is applied.

4.3. Do spreads affect growth or vice versa? A VAR-approach

To prove whether spreads affect growth rates and vice versa, we propose a simple VAR model in reduced form. Hence, there is no need to impose additional restrictions on our model to ensure that one can identify the coefficients. Accordingly, our model takes the following form.

$$\begin{pmatrix} \Delta y_t \\ spread_t \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + \sum_{j=1}^p \begin{pmatrix} \beta_{11j} & \beta_{12j} \\ \beta_{21j} & \beta_{22j} \end{pmatrix} \begin{pmatrix} \Delta y_{t-j} \\ spread_{t-j} \end{pmatrix} + \begin{pmatrix} \chi_1 \\ \chi_2 \end{pmatrix} I_{t-1} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \quad (3)$$

To determine the appropriate lag structure denoted p, the Akaike, the Bayesian Schwarz and the Hannan-Quin information criteria are calculated. All criteria favor a model with one lag. The lag structure of the inversion indicator variable can be figured out by inspecting the cross-correlogram. A peak is reached at the first lag with

a negative correlation of about -0.2991. The correlation between inversions with two lags and current growth rates is still -0.1905. However, one lag should be sufficient to capture the effect of inversions on growth rates. Carrying out the VAR estimation for the whole period, we obtain the results presented in table 3. Note that a VAR for the whole period is rather problematic, as the model might differ considerably among sub-periods. Consequently, section 4.5 provides evidence on the appropriate model for each monetary regimes.

The results are highly interesting, as the spread has the alleged positive impact on growth rates. The magnitude of the coefficient is high, especially, when compared to the influence of growth rates on spreads. Noteworthy, inversions cannot predict changes in growth rates, albeit inversions were the only reliable indicators for the pre-1914 period. This impression is further confirmed by applying Granger causality tests; thereby, both directions of causality can be confirmed – arguing on the 90% level of confidence – as shown in table 4. Accordingly, neglecting the impact of growth rates on spreads may bias our former results and also the outcomes of Bordo and Haubrich (2004).

4.4. Structural breaks due to regime shifts

The next step is to think about structural breaks in our VAR model due to regime shifts; thereby, several methods could be applied.⁵ First of all based on Clements and Hendry (1996), one can state that VAR in first differences are more robust compared

⁵ Bai, Lumsdaine, and Stock (1998) introduced a method to detect structural breaks in VAR models. Their procedure can be applied to individual equations as well as to the whole system of a VAR model. Bekaert, Harvey, and Lumsdaine (2002) discussed the former method and stressed the capability of the approach due to Bai and Perron (1998a, b) who allowed for multiple breaks.

to VAR with error correction term, as the long-run equilibrium might change due to structural breaks. However, corrections of the intercept might help to improve the performance of VECM models. Therefore, our former results should be less affected by structural changes than other models. Nevertheless, our aim is to discuss whether the predictability and, hence, the credibility differs among monetary regimes in Germany. Accordingly, we try to identify structural breaks in our sample motivated by historical evidence and test how many breaks are required.

We propose a very simple procedure; thereby, the included structural breaks are known regime shifts, namely the Classical Gold Standard, the interwar period, the Bretton Woods system, and the period of free-floating after 1971. Inserting intercept and slope dummies into the single equations of our VAR approach permits regime shifts. The estimated sum of squared residuals serves as a litmus test whether the respective number of regimes should be assumed. Following Bai and Perron (1998a, b), we try to find the number of structural breaks that minimize the sum of squared residuals. Note that following Bai and Perron (1998a, b) is less promising due to the gaps in our series, which coincide with regime shifts. Henceforth, estimating the date of break points becomes in this case a risky venture. Nevertheless, we can confirm by calculating the sum of squared residuals that four regimes as mentioned above should be assumed.⁶ Based on these outcomes, table 5 summarizes the estimated VAR models for different sub-periods. Note that the table just contains the equation with growth rates as dependent variable to save space, as the predictability of economic

⁶ Results for the sum of squared residuals reaches 962.85 in the case of four regimes. If the number of regimes declines by one (no shift after Bretton Woods in 1971) the sum is 985.70. A further reduction of regimes increases the sum of squared residuals to 1015.10 and finally to 1092.50 if a structural break is solely allowed for the Classical Gold Standard period.

growth observing past inversions and spreads is our focus. By looking at the adjusted R-squared for the sub-periods, one can argue that the predictability is lowest during the Classical Gold Standard and highest in the interwar period. Bretton Woods and the free-float era are even less reliable than the pre-1914 period.

4.5. Quality of forecasts: VAR versus ARMA predictions

Besides focusing on the magnitude of impact of spreads on future growth rates, we want to discuss the quality of forecasts by inspecting previous spreads. Therefore, we compare one-step ahead forecasts for growth rates applying our VAR model and a simple AR(1) model, respectively.⁷ Following Diebold and Mariano (1995), the mean-square errors (MSE) of the forecasts obtained by a VAR and an AR(1) model are determined. The Diebold and Mariano (1995) test procedure reveals whether the difference in MSE is significant. Table 6 summarizes the MSE for every sub-period and indicates whether a simple AR(1) process outperforms the models that account for spreads. The outcomes point in the same direction as our former results; however, some points are worth mentioning. During the Classical Gold Standard, a simple AR(1) process applied to economic growth rates clearly outperforms predictions based on previous spreads. This is an additional hint that the predictive power of spreads was low, and hence the Classical Gold Standard could be regarded as highly credible. Contrary, the interwar period exhibited a relatively high predictability using spreads. This is in line with our former VAR outcomes, and underlines the high extent of incredibility of the monetary regime during the Hyperinflation. Noteworthy, based on MSE, we find differences between the Bretton-Woods period and the free-float

⁷ An AR(1) model is the best ARMA specification for economic growth rates based on ACF and PACF plots as well as information criteria.

system; spreads are useful to improve the predictability after the Bretton-Woods agreement broke down. The fixed-exchange rate system, consequently, had a higher credibility compared to a free-float system.

4.6. Changes of credibility in different monetary regimes

Another way to look at the change in predictability and credibility of monetary regimes over time is to apply rolling regressions to our VAR specification. Accordingly, shifts in parameters are permitted and estimations are based on a nine-year window that is moved after estimation one year ahead. Based on these estimated coefficients for the partial impact of previous spreads on current economic growth rates, one can assess how the interrelation underwent changes during more than one century of regulatory development. The limitations of this often-applied method are obvious, as our sample exhibits considerable gaps caused by the two World Wars and the break down of the bond market during the Hyperinflation. Despite the shortcomings related to our sample, we define nine-year windows and obtain coefficients for the rolling regressions. This gives us a clue about the timing of regime shifts and changes within one alleged regime.

4.6.1. Credibility during the pre-World War I period

Figure 4 underlines that the magnitude of impact of former spreads on current growth rates underwent a considerable change from 1870 to 1913. Note that by construction of the rolling regressions, our sub-period starts in 1875, which means that all observations from 1871 to 1879 are considered to produce this single estimate. At the beginning of this sub-period, spreads negatively affected economic growth rates, while after 1880 we have a shift to a rather strong positive significant impact reaching

its peak in 1889. In the following the coefficients declined considerably and reached the lowest levels at the end of the period, namely in 1909. However, one should have in mind that only the period from 1888 to 1892 and 1896 to 1901 exhibited significant coefficients. During these periods, spreads always had a positive impact on future growth rates as predicted by theoretical considerations. Nevertheless the observed pattern is striking because it underlines that in spite of the quite early introduction of the Gold Standard in Germany in the first half of the 1870s the market obviously needed some time to build up market participants' credibility for this new monetary system. One reason might be the late foundation of the Reichsbank in 1876. During its first years, the gold reservoir rapidly declined from 500 million Marks to 207 million Marks in 1882 (see Helfferich, 1898). Thus, the success of this new regime was not clear at all, and - considering the deflationary circumstances - it took the Reichsbank some time to gain the necessary faith of the investors as an absolute secure "lender of last resort" (see Nocken, 1993). After these starting problems, the German credit- and currency-system did not work without problems – but without bigger financial crises up to World War I. The growing credibility during a period of low persistence of inflation rates can be well observed in the reduced impact of spreads on future economic growth.

4.6.2. Credibility during the interwar period

After the gap due to the First World War and the Hyperinflation in the early 1920s, the period from 1926 to 1939 exhibited a rather high magnitude of impact of the yield spread on economic growth (see figure 5). These results of the interwar period reflect the low investors' reliance in the current monetary system after the experiences of Hyperinflation and the Great Depression. Nevertheless, one should keep in mind that

the interpretation for this sub-period by applying rolling regressions can only be done in a limited way considering the gaps in our data.

4.6.3. Credibility during the after World War II period

After the Second World War, we have the longest coherent sub-period of the whole sample. The pattern of the coefficients is striking as well. Overall, the influence of spreads declined remarkably compared to the interwar period – with the exception of the period from 1955 to 1966. During these twelve years the impact of spreads increased rapidly to an all-sample peak in 1963. Even if the standard deviations are high, and, thus, these coefficients are not significant, it is worth thinking about this development that is astonishing at a first glance. Interpretation of these results in the sense of Bordo and Haubrich (2004) means that there was an immense loss of credibility in the monetary system of Germany in the second half of the Bretton Woods era. It is also noteworthy that the market participants' credibility seemed to strengthen again during the following free-float period. From 1969 onwards, coefficients are usually significant, and one observes a downward tendency regarding the magnitude of impact of spreads. One might have expected results the other way around considering that the characteristics of the Bretton Woods-system were the fixed currencies system depending on the US-dollar and the gold. Thus, we would expect results comparable to the pre-World War I period that we can indeed observe during the first years of the Bretton Woods agreement. Obviously, the market seemed to anticipate the insufficiency of the system, which is explicitly named by the so-called Triffin-paradox. The necessity of liquidity automatically supported a loss of faith in the system (see Bordo and Eichengreen, 1993).

The following results during the free-float period can be interpreted in light of the improvement in monetary control and credibility of the central bank. Referring to the results of rolling regressions, we can state that the improvement of reliable commitments in tackling the issue of inflation persistence is confirmed by the reduction in the magnitude of impact of spread on future economic growth rates.

4.7. The impact of spreads on monetary policy during the pre- World War I period

This section deals with the interrelations among inflation rates, growth rates, and short-term interest rates set by the 'Reichsbank'. This paragraph serves two purposes, namely to test hypotheses on the alleged impact of inflation and real economic shocks on short and long-term interest rates and to assess whether spreads affect the policy of the central bank. The first aspect is relevant to confirm the linkage between predictability and credibility. The latter issue is credential when dealing with different monetary regimes, as some regimes might be sensitive to changes in spreads and hence react with a revision of former policies. Bordo and Haubrich (2004) completely overlooked this issue. Yet Gamber (1996) highlighted this causality problem in his paper on the U.S. market. If the 'Reichsbank' was less sensitive to changes in spread and did not change short-term rates to stimulate growth, the impact of spreads on future economic growth is limited. This might – besides the strong commitment to fight against inflation – provided additional explanation for the low predictability during this period.

Focusing on the period of the Classical Gold Standard, Bordo and Haubrich's (2004) hypotheses, which they confirm for the U.S. economy, are tested with our German dataset. This is essential to understand the linkage between predictability and credibility. The first hypothesis states that under the Gold Standard or a so-called Fiat

system, which is a system with fixed price levels, inflation shocks should trigger higher short-term interest rates – but should not affect long-term rates. This assertion is due to the fact that under a system that guarantees long-term price stability, inflation is just a temporary perturbation and the long-run expectation of inflation approaches zero. Henceforth, sudden increases in inflation rates only yield higher short-term interest rates. To test these hypotheses, our VAR model (3) includes now growth rates, inflation rates, the private discount and the average bond yield.

$$\begin{pmatrix} \Delta y_t \\ \text{inf}_t \\ pd_t \\ bond_t \end{pmatrix} = \alpha + \sum_{j=1}^p \Gamma_j \begin{pmatrix} \Delta y_{t-j} \\ \text{inf}_{t-j} \\ pd_{t-j} \\ bond_{t-j} \end{pmatrix} + \varepsilon_t \quad (4)$$

The second hypothesis states that under the Gold Standard or a Fiat regime, real economic shocks only influence short-term interest rates. Using the model setting described in (4) enables to test both hypotheses. Derived from the estimated impact multipliers and a bootstrapping approach, figure 6 depicts the impulse responses of bond yields and short-term interest rates triggered by a real economic shock. As the picture for inflation rate shocks is pretty similar, the impulse responses are omitted. The upper and lower boundaries of the 95% confidence intervals reveal that real economic shocks only affect short-term interest rates significantly, while bond yields remain unchanged. Therefore, our impulse response functions confirm Bordo and Haubrich's (2004) hypotheses for the German case. The interpretation of this finding is as follows. If inflation and real economic shock both affect the short- but not the long-term interest rates, the impact on the spread is similar. Hence, observing a change in spreads provides just a 'noisy signal' about future economic growth, as changes of the spread could have to reasons – inflation and real economic shocks. A credible system should, thus, exhibit a low predictability.

After modifying model (4) by inserting the spread and the discount rate set by the 'Reichsbank', we can assess whether the spread affects the monetary policy of the 'Reichsbank'. Table 7 shows the Granger causality tests that indicate that the 'Reichsbank' set their interest rates according to former growth rate and inflation rates – but not based on previous spreads. There is, consequently, no linkage between spread and monetary policy. If the spread had affected growth rates, this effect would have been a direct one. Hence, we can state that based on the hypotheses stated by Bordo and Haubrich (2004) spreads are a noisy signal for future economic growth. In addition, spreads do not affect the policy of the 'Reichsbank'; hence, both facts limit the predictability of future economic growth and explain our finding.

4.8. Results using Burhop and Wolff's (2005) compromise estimates

Whether Hoffmann's (1965) estimates of economic growth rates are reliable is a disputable topic in current research. To account for this enduring debate, we use the recalculated time series provided by Burhop and Wolff (2005) and re-estimate our VAR model with and without inserting inversions. Table 8 reports our results and emphasizes that predicting the Hoffmann (1965) growth series, or the Burhop and Wolff (2005) compromise estimate is an easy task. The R-squared is even lower when one tries to forecast the compromise estimate. Henceforth, our former results and interpretations are not affected by these new estimates. Can we claim that the Hoffmann (1965) series is closer to the true development, as our model exhibits a higher predictability? From our point of view, we are not able to make such a statement because finding a low predictability fits better to the considerations of Bordo and Haubrich (2004). The Classical Gold Standard shows the lowest predictability and using the revised GDP estimates the predictive power is even lower.

Consequently, one can state that the Classical Gold Standard possessed a high credibility during this time. Burhop and Wolff's (2005) compromise estimates fit better into this picture than the Hoffmann (1965) time series; however, it stays an open debate in economic history.

5. Conclusion

The period of the Classical Gold Standard exhibited the weakest possibility to build up precise expectations regarding future economic growth. An exception is the role of the several inversions of the yield curve, which indicated almost always a considerable cooling of economic activities. The interwar period showed the highest model fit with a R-squared of about 0.62. By observing former spreads and the past development of economic growth, sophisticated predictions were possible. When we interpret our finding in the sense of Bordo and Haubrich (2004), one can state that the interwar period was highly insecure regarding the credibility of the monetary policy. During the Bretton Woods period and afterwards, the predictability declined remarkably. Yet if one combines both periods and forms a post-World-War II period, a sufficient level of predictability can be confirmed. Nevertheless, the R-squared just reaches 0.28 by far less than during the interwar period.

Looking closer on the single sub-periods, our rolling regressions detect - by following the argumentation of Bordo and Haubrich (2004) - that building up market participants' credibility in the Classical Gold Standard period took more time than commonly expected. Only from the 1890s onward, we can observe a reduction of the impact of spreads on future economic growth and hence an increase in the credibility of the regime. That means that the turbulent 1870s in Germany with the introduction of the Gold Standard, the new uniform currency and the changing inflationary and

deflationary tendencies cast a longer shadow to the investors' faith in the stability of the new system than commonly expected.

A second striking change in investors' credibility of the respective system can be observed during the second half of the Bretton Woods era. Our proxy for monetary system credibility impressively shows the decreasing tendency around 1960. Thus, at a point of time when the system was officially not yet put into question the market already seemed to anticipate the problems and, thus, the collapse of the system.

Going along with estimates for the U.S. the Classical Gold Standard period in Germany reveals no linkage between spreads and monetary policy. This might be an additional explanation for the limited predictability during the pre-1914 period. The recalculated GDP-time series by Burhop and Wolff (2005) shows an even lower predictive power than the classical Hoffmann (1965) series, which fits better into the picture of credibility.

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Table 1. Data sources

	Data sources		
	Short-term	Long-term	GDP
1870 – 1913	Private discount Donner (1936, 98 ff.)	Average bond yields Donner (1936, 98 ff.)	Hoffmann-index Hoffmann (1965, 825 ff.)
1925 – 1939	Private discount Deutsche Bundesbank (1976, 278 f.)	bond yields Deutsche Bundesbank (1976)	Deutsche Bundesbank (1976, 6 f.)
1950 – 1974	1950 – 58: call money rate Morawietz (1994, 341 f.) 1959 – 74: private discount Deutsche Bundesbank (1976, 278 f.)	bond yields Deutsche Bundesbank (1976)	Deutsche Bundesbank (1976, 6 f.)
1975 – 2003	3-months Treasury rate Statistisches Bundesamt	10-years `Bundesanleihe` Statistisches Bundesamt	Online database provided by Deutsche Bundesbank

Table 2. Results of the standard model with inversions

Explanatory variables	Classical Gold Standard	Interwar period	Bretton Woods period	Free-float period
Constant	4.1196 (0.002)	1.0022 (0.919)	5.3238 (0.129)	1.8042 (0.084)
Spread _{t-1}	-0.8479 (0.530)	1.8864 (0.405)	0.5760 (0.659)	0.4029 (0.453)
Inversion I _{t-1}	-3.7423 (0.064)	-	-	-1.1840 (0.485)
Δy_{t-1}	0.0484 (0.739)	0.6725 (0.237)	0.3424 (0.352)	0.1670 (0.409)
Wald test	5.20 (0.158)	1.52 (0.468)	0.95 (0.623)	3.52 (0.319)
Observations	43	14	20	33

P-values are set in parentheses. Coefficients that are significant on the 95% level of

confidence are shaded.

Table 3. Results of the VAR model for the whole period

	Dependent variable: growth rates	Dependent variable: spread
Constant	0.8716 (0.121)	0.5743 (0.003)
Growth _{t-1}	0.3944 (0.000)	-0.0423 (0.064)
Spread _{t-1}	0.8800 (0.000)	0.6926 (0.000)
Number of Observations	108	108
R-squared	0.26	0.48

P-values are set in parentheses. Coefficients that are significant on the 95% level of

confidence are shaded.

Table 4. Granger causality tests for growth rates and spreads

	Dependent variable: growth rates	Dependent variable: spread
Growth _{t-1}	-	12.31 (0.001)
Spread _{t-1}	3.43 (0.064)	-

P-values are set in parentheses. Coefficients that are significant on the 95% level of confidence are shaded.

Table 5. VAR model for every sub-period

	Classical Gold Standard	Interwar period	Bretton Woods system	Free- floating system	Pre-1945 period
Growth _{t-1}	0.1223 (0.401)	0.6442 (0.000)	0.4108 (0.160)	0.1218 (0.448)	0.4573 (0.000)
Spread _{t-1}	-0.8599 (0.470)	2.4868 (0.013)	0.8558 (0.373)	0.3057 (0.436)	0.8485 (0.021)
I _{t-1}	-3.8366 (0.079)	-	-	-1.1995 (0.452)	0.1304 (0.942)
Observations	43	13	19	33	52
R-squared	0.10	0.62	0.09	0.15	0.36

P-values are set in parentheses. Coefficients that are significant on the 95% level of confidence are shaded. Constant terms are not reported, as they are irrelevant for our interpretation.

Table 6. MSE of forecasts based on VAR and AR(1) model

	Classical Gold Standard	Interwar period	Bretton Woods system	Free-floating system
MSE based on VAR	13.06	15.29	10.19	5.08
MSE based on AR(1)	9.04	22.62	10.67	5.77
Diebold – Mariano statistic	2.51	-2.65	-1.15	-2.78
p-value	0.012	0.008	0.251	0.005

Shaded cells indicate that the respective model outperforms significantly measured by the mean-square error (MSE).

Table 7. Granger causality tests

	Growth	Inflation	RB discount	Spread
Growth	-	0.1463 (0.702)	4.9609 (0.026)	9.3694 (0.002)
Inflation	0.4272 (0.513)	-	12.6920 (0.000)	20.7018 (0.000)
RB discount	4.0956 (0.043)	4.5795 (0.032)	-	0.0009 (0.976)
Spread	0.7311 (0.393)	4.1190 (0.042)	0.6608 (0.4163)	-

P-values are set in parentheses. Coefficients that are significant on the 95% level of confidence are shaded.

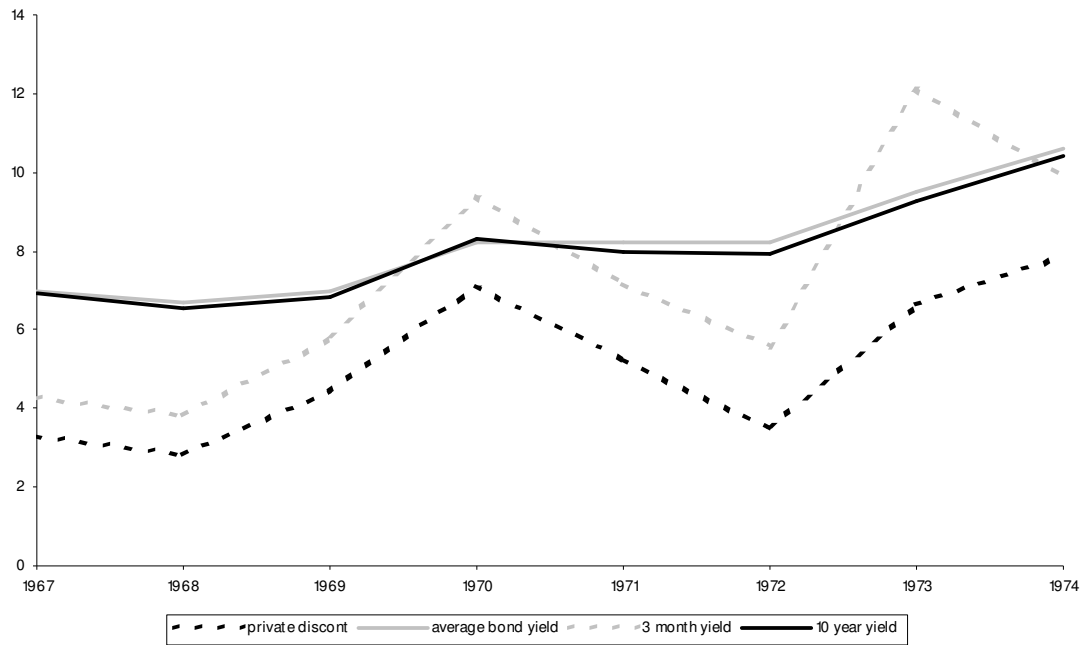
Table 8. VAR model for pre-1914 period with Burhop and Wolff's (2005) data

	Dependent variable: growth rates	Dependent variable: spread	Dependent variable: growth rates	Dependent variable: spread
Constant	3.1634 (0.000)	0.3461 (0.183)	2.7183 (0.000)	0.1631 (0.395)
Growth _{t-1}	-0.0734 (0.627)	0.0309 (0.586)	-0.0554 (0.714)	0.0383 (0.501)
Spread _{t-1}	-0.1940 (0.719)	0.3663 (0.070)	0.1826 (0.616)	0.5211 (0.000)
Inversion _{t-1}	-0.9357 (0.348)	-0.3847 (0.304)	-	-
Number of Observations	43	43	43	43
R-squared	0.03	0.28	0.01	0.26

P-values are set in parentheses. Coefficients that are significant on the 95% level of

confidence are shaded.

Figure 1. Four measures for short- and long-term interest rates.



This figure plots for the overlapping period 1967 to 1974 all four measures for short- and long-term interest rates.

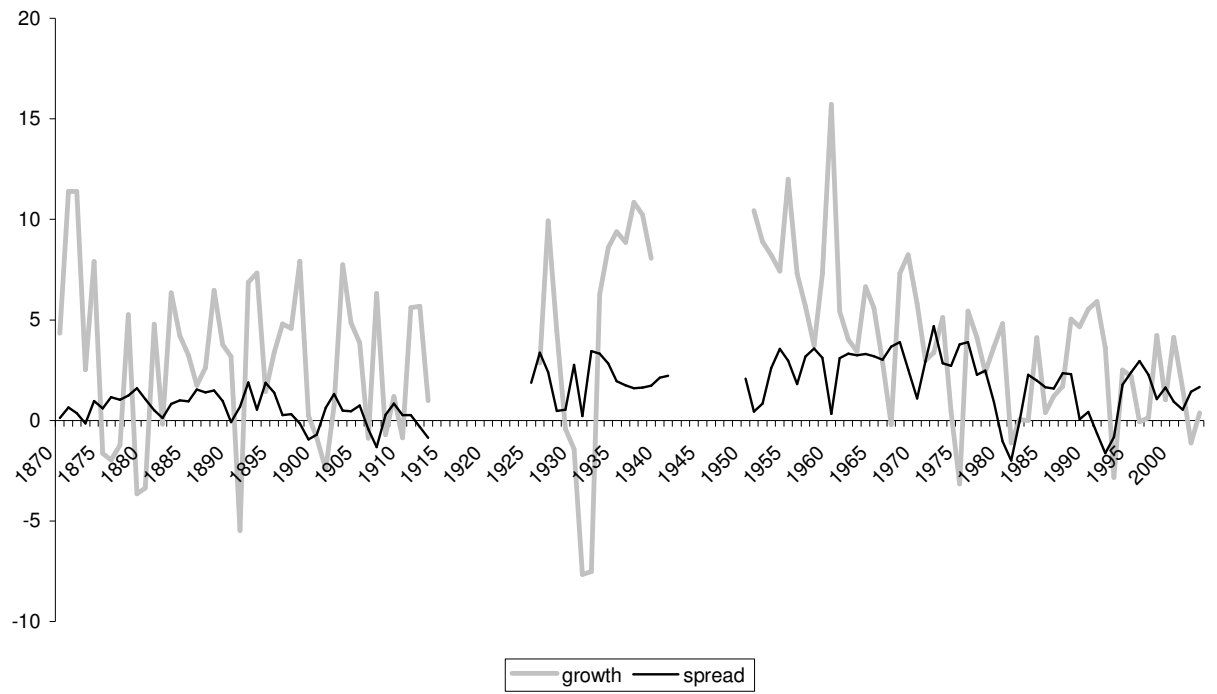
Figure 2. Spreads and growth rates from 1870 to 2003

Figure 3. Inversions during the classical Gold Standard

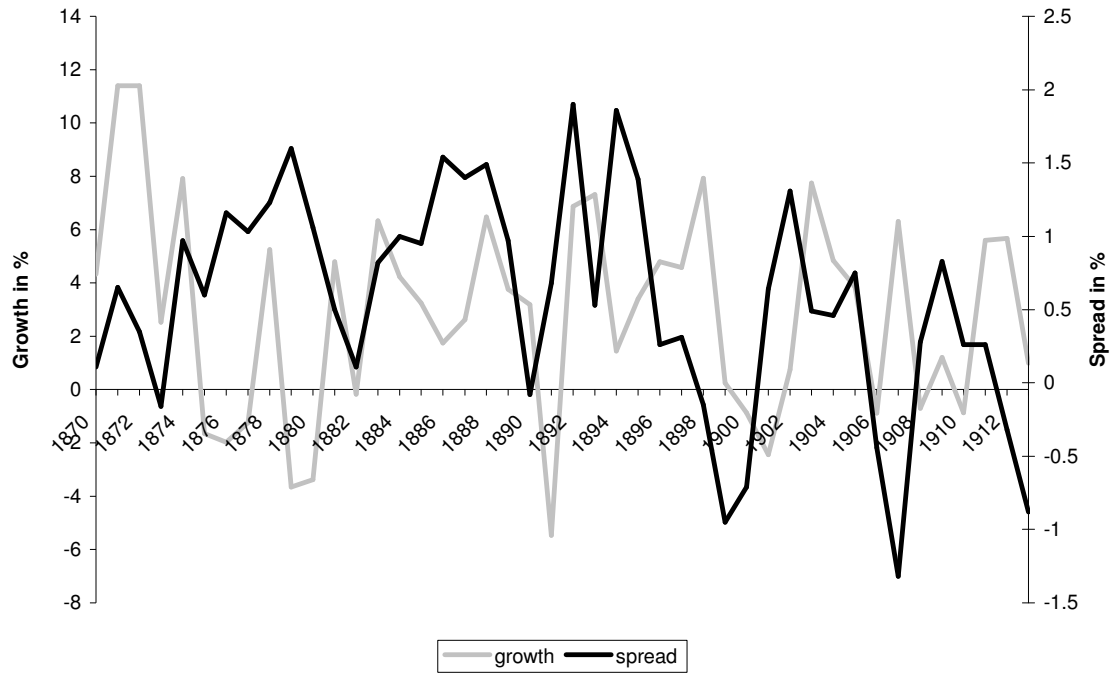
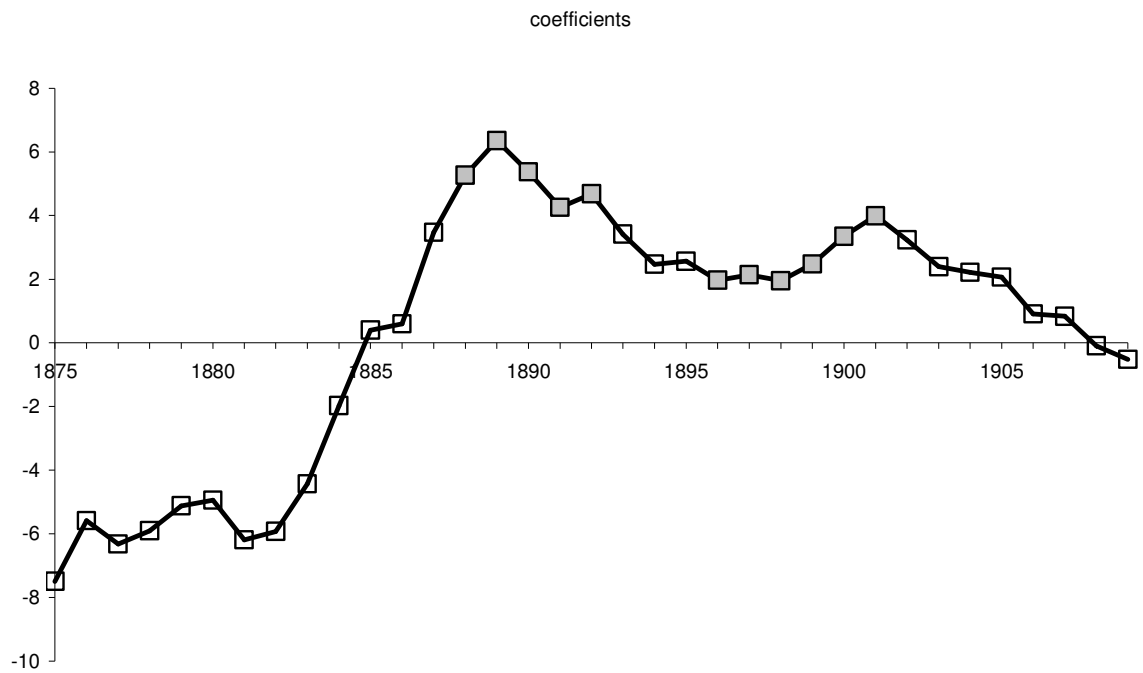
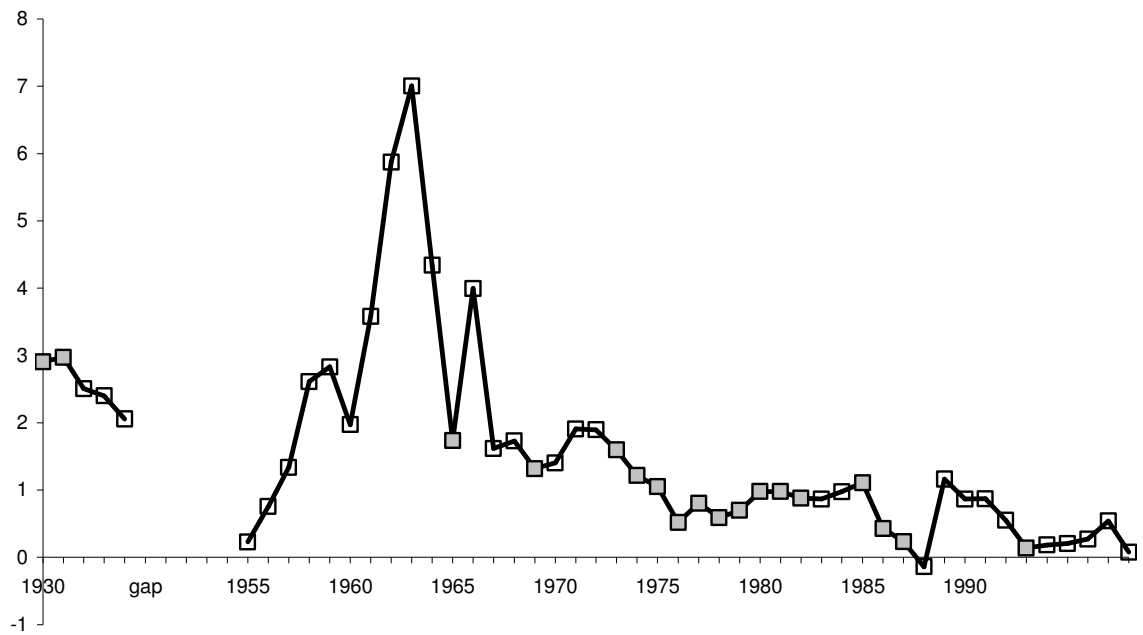


Figure 4. Magnitude of impact of the spread on economic development pre-1914



To assess the significance of the respective coefficients, shaded cells indicate that the coefficient is significantly different from zero on the 95% level of confidence.

Figure 5. Magnitude of impact of the spread on economic growth after 1925



To assess the significance of the respective coefficients, shaded cells indicate that the coefficient is significantly different from zero on the 95% level of confidence.

Figure 6. Impulse responses of short and long-term interest rates triggered by real economic shocks

