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Feedback Trading and Predictability of Stock Returns in Germany, 1880–1913

by

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Abstract

I use a time-varying parameter model in order to study the predictability of monthly real stock returns in Germany over the period 1880–1913. I find that the extent to which returns were predictable underwent significant changes over time. Specifically, predictability of returns, as measured by their first-order autocorrelation coefficient, was positive most of the time. It tended to be significant during extended periods of stock market decline, but not during periods of stock market increase. I argue that this time-pattern of predictability of returns is consistent with feedback effects of futures trading on the spot market.

Keywords: Stock market; Return Predictability; Germany

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1. Introduction

An important foundation of modern finance theory is the Efficient Market Hypothesis. This hypothesis rests on the assumption that the information set used by agents to form their rational forecasts of future expected returns contains all the information relevant for the pricing of financial securities. According to the so-called weak form of the Efficient Market Hypothesis, a financial market is called weakly efficient if this set of information incorporates all the information already embedded in past returns (Fama 1970, 1991). Hence, in a weakly efficient financial market, returns are not predictable in the sense that it is not possible to forecast returns in a particular month by using returns observed in a previous month. Given the key importance of the Efficient Markets Hypothesis for modern finance theory, predictability of returns has always been an important research topic in the empirical finance literature. Most authors who have contributed to this literature have used data for modern stock markets to study predictability of returns. I complement these studies by analyzing the predictability of monthly real returns in the German stock market during the period 1880–1913.[1]

A number of competing explanations for predictability of returns have been developed in the "noise trader" literature. Noise traders are agents who behave "irrationally" in the sense that their investment decisions are not entirely determined by economic fundamentals. If a sufficiently large proportion of all traders acting in a stock market behave as noise traders, then stock prices can, at least temporarily, deviate from economic fundamentals (DeLong et al. 1990). This deviation of stock prices from economic fundamentals can imply autocorrelation and, hence, predictability of returns. Specifically, predictability of returns can arise if noise traders follow so called feedback trading strategies (Cutler et al. 1990). Positive feedback trading involves buying stocks when prices have risen and selling stocks when prices have fallen. Negative feedback trading, in contrast, requires just the opposite: buying stocks when prices have fallen and selling stocks when prices have risen. Positive feedback trading should result in negative

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[1] For studies of the efficiency of the pre-World War I German stock market, see also DeLong and Becht (1992) and Wetzel (1996).

autocorrelation of returns because it gives rise to a short-run overreaction of stock market prices to, e.g., news about dividends. Negative feedback trading, in contrast, should result in positive autocorrelation of returns.

I study whether feedback trading played an important role for stock market fluctuations in Germany before World War I. In order to answer this question, I estimated a regression model with time-varying parameters. I used a model with time-varying parameters because the reports of then-contemporary commentators of the German stock market in the nineteenth century suggest that feedback trading did influence stock market fluctuations, but that this influence changed over time. I found that, for most of the time, the predictability of returns in Germany before World War I, as measured by the first-order autocorrelation coefficient, was positive. This positive autocorrelation of returns is consistent with empirical results that, beginning with Cowles and Jones (1937), have been reported in numerous contributions to the empirical finance literature. However, the time-series properties of autocorrelation of returns in the German stock market before World War I differ from those of many other markets insofar as autocorrelation tended to be significant during extended periods of stock price decreases, but not during periods of stock price increases. This result suggests that negative feedback trading played an important role for the dynamics of returns during periods of stock market decreases, and that its effect on returns was less significant during periods of stock market increases.

This is an interesting result because the empirical evidence available for modern stock markets indicates that positive feedback trading tends to be an important driving force of predictability of returns when stock markets are declining (Sentana and Whadwani 1992; Koutmos 1997). Hence, there is a remarkable difference between the results I obtained for the pre-World War I German stock market and the results available for twentieth century stock markets. This difference gives rise to the question whether the time-varying predictability of returns in nineteenth century Germany was caused by feedback trading, or whether I should explore one of the other explanations for return predictability that have been put forward in the finance literature. Therefore, I study in detail the sources of predictability of returns in the German stock market before World War I. The results of this study suggest that feedback trading is the most promising candidate for explaining both the magnitude and the time-pattern of predictability of returns I found in my empirical analysis.

What was the source of feedback trading in the German stock market before World War I? In order to answer this question I compared the narrative evidence reported by then-contemporary economists with my estimation results. This comparison revealed that the pattern of autocorrelation of returns I found in the data could reflect feedback effects of futures trading on the spot market. Given the quantitative importance of futures trading before World War I, this is a view that was also held by many then-contemporary economists.[2] Specifically, many then-contemporary economists argued that trading in the futures market could give rise to what we today call “negative feedback trading”. They also argued that feedback effects of trading in the futures market on spot market dynamics were particularly strong in extended periods of stock market decline.

This argument was based on the intuition that in periods of stock market decline those investors who were mainly active in the futures market sold stocks short. Hence, these investors were engaged in futures trading on declining stock prices. This trading implied a negative feedback trading strategy in the spot market because, while stock prices continued declining, the investors in the futures market started to cover their open short positions (or to carry them forward to the next month). This required purchasing stocks in the spot market (*Deckungskäufe*). In such a situation, even a shortage of shocks (*Stückemangel*) could arise if other traders like, for example, banks, long-term investors, or “uninformed” investors were not willing to sell their stocks. As a result, the downward pressure on stock prices was eased. In consequence, it took longer for

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2 Significant feedback effects of futures trading on spot market dynamics could arise because futures contracts played a very important role for stock trading in nineteenth century Germany. For example, Gömmel (1992) has estimated that in 1880 approximately 60% of all transactions on the Berlin stock exchange, the most important market place for stock trading in Germany before World War I, involved futures contracts on stocks.

stock prices to decline, and the autocorrelation of returns became significantly positive.[3]

While this stabilizing property of futures trading was in general acknowledged in the economics literature, it did not remain undisputed. In fact, this dispute was one important element in the debate on the German Securities Exchange Law (*Deutsches Börsengesetz*) which was entered into force in 1896.[4] Among other things, this law restricted futures trading in the stocks of mining and industrial companies.[5] Many economists including Desenberg (1904) and Wermert (1904) argued that this restriction of futures trading brought about an increase in stock market volatility because the purchases by traders in the futures market could no longer exert their stabilizing effect on stock prices in periods of stock market downturns. Advocates of futures trading argued that because the futures market was larger and more liquid than the spot market, it guaranteed less volatile stock prices (see, e.g., Cohn 1895, pages 71-72).[6]

Other economists were more skeptical in this regard. For example, Prion (1910) argued that the stabilizing role of futures trading had been overstated by other researchers.[7] He acknowledged that, in theory, stock price decreases would

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[3] In periods of increasing stock prices, trading in the futures market required taking long positions in stocks, not short positions. Thus, trading in the futures market on an increase in stock prices could not give rise to a shortage of stocks, and this made, according to Prion (1910, page 88), futures trading on increasing stock prices less difficult and risky than futures trading on decreasing stock prices.

[4] Concerns that trading in the futures market could destabilize the spot market led to the formation of a Stock Exchange Commission (*Börsenenquetekommission*) in 1882/1893. The hearings of this commission formed the basis for the German Securities Exchange Law of 1896.

[5] However, agents developed business practices that allowed them to circumvent the restrictions of the German Stock Exchange Law of 1896. Thus, de facto, a futures market for these stocks existed even after 1896. See, e.g., Prion (1910, page 160) for a discussion of this. See also Wetzel (1996) for a quantitative study of the impact of the German Stock Exchange Law of 1896 on the German stock market. Wetzel has reported that the volume of futures trading decreased after 1896.

[6] This was also the position of the representatives of German banks. See Centralverband des deutschen Bank- und Bankiersgewerbes (1903, page 26).

[7] A similar position was taken by Bachmann (1898). See the book review by Spiethoff (1900). See also Prion (1930), who also provides a useful discussion of technical

trigger stabilizing purchases by traders in the futures market (page 90). However, based on visual inspection of time-series of stock prices, he argued that futures trading made stock prices more volatile.[8] He also argued that it, on average, resulted in larger deviations of stock prices from their respective fundamental values (*innerer Wert*). Prion concluded that, whenever a period of declining stock prices began, *Deckungskäufe* implied by short selling in the futures market did not, or did so only after a delay, dampen the downward pressure on stock prices.[9] I argue that my empirical evidence does not lend support to the argument that futures trading typically did not unfold a stabilizing effect in extended periods of declining stock prices.

I organize the remainder of this paper as follows. In Section 2, I describe the theoretical and the empirical model I used to study the predictability of returns. In Section 3, I describe the data I used in my empirical analysis. In Section 4, I present my estimation results. I also discuss whether predictability of returns reflected the feedback effects of futures trading or whether it was caused by other factors like, e.g., a time-varying risk premium. Furthermore, I discuss whether my estimation results are in line with the reports of then-contemporary commentators on the German stock market. In Section 5, I offer some concluding remarks.

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details of futures and spot market trading of stocks on the Berlin stock exchange. Prion (1910, pages 171-196) and Wetzel (1996, pages 270-276) have provided useful summaries of studies of then-contemporary economists on the impact of the German Stock Exchange Law of 1896 on the link between futures trading and spot market developments.

8 For quantitative evidence that the restrictions on futures trading codified in the German Stock Exchange Law resulted in a decrease in stock market volatility, see Wetzel (1996).

9 "*Zieht man die Erfahrungen der früheren Zeit zu Rate, so ist keine Behauptung gewagter als die, dass die Baissespekulation in kritischen Zeiten große Kurssprünge verhindere.*" [If one takes the historical experience into account, one cannot say that bearish speculation prevents large jumps of stock prices during critical times.] (Prion 1910, page 181). See also his comments on the role of futures speculation for the impact of the Russian-Japanese war of 1904 on European stock exchanges: „*Die in der Theorie so beliebten Deckungskäufe, die die Kursschwankungen mildern sollen, bleiben in der Praxis in solchen Momenten aus, und an ihre Stelle treten neue Abgaben, um die Baissespekulation möglichst lohnend zu machen.*" [The *Deckungskäufe*, that have been so popular in theoretical studies and that are supposed to smooth out stock price fluctuations do not take place in practice in such situations [e.g., during wars]; rather additional sales of stock prices take place in order to make selling short as profitable as possible.] (page 194).

2. Modeling Predictability of Returns

This section comes in two parts. In the first part, I briefly describe the theoretical model I used to analyze the implications of feedback trading for the predictability of returns (Section 2.1). In the second part, I describe the empirical model I estimated to analyze the possibly time-varying predictability of returns (Section 2.2).

2.1 Theoretical Model

The theoretical model builds on Shiller (1984) and Sentana and Whadwani (1992). Their models rest on the assumption that two different groups of traders populate a stock market. The first group of agents is called "smart money" traders because their demand for stocks is governed by risk-return considerations:

$$Q_{1,t} = (E_{t-1}R_t - \alpha_t) / \mu_t, \tag{1}$$

where $Q_{1,t}$ denotes the proportion of smart money traders in the market, α_t denotes the return at which the demand for stocks by smart money traders is zero, and μ_t is the risk-premium for holding stocks. I assume that both α_t and μ_t may change over time. If only smart money traders were active in the stock market then $Q_{1,t} = 1$ and stocks were priced according to Merton's (1980) Capital Asset Pricing Model.

The second group of agents is feedback traders. Their demand for stocks can be described by means of the following equation:

$$Q_{2,t} = \gamma_t R_{t-1}, \tag{2}$$

where $Q_{2,t}$ denotes the proportion of feedback traders in the market. If $\gamma_t > 0$, then feedback traders adhere to a positive feedback trading strategy, i.e., they buy (sell) stocks when the prices of stocks have risen (fallen). If, in contrast, $\gamma_t < 0$, feedback traders follow a negative feedback trading strategy, i.e,. they buy (sell) stocks when the prices of stocks have fallen (risen). I allow for changes over time in the parameter γ_t in order to account for changes in the influence of feedback traders who follow a positive or negative feedback trading strategy.

Upon invoking the assumption of rational expectations, $R_t = E_{t-1}R_t + \varepsilon_t$, and the condition for stock market equilibrium, $Q_{1,t} + Q_{2,t} = 1$, one obtains the following difference equation with time-varying coefficients:

$$R_t = \beta_{0,t} + \beta_{1,t}R_{t-1} + \varepsilon_t, \tag{3}$$

where ε_t denotes a stochastic disturbance term and $\beta_{0,t} = \alpha_t + \mu_t$ and $\beta_{1,t} = -\gamma_t\mu_t$. Equation (3) shows that changes in the parameter that captures the predictability of returns, $\beta_{1,t}$, can result from changes in the parameter that reflects the influence of feedback traders, γ_t, and changes in the risk premium for holding stocks, μ_t. Hence, an important question is whether changes in the parameter $\beta_{1,t}$ are caused by changes in the predictability of returns or changes in the risk premium. I will address this question in Section 4.3 below.[10]

2.2 *Empirical Model*

In order to estimate Equation (3), I used a time-varying parameter model that is similar to the models that Zalewska-Mitura and Hall (1999) and Rockinger and Urga (2000, 2001) have recently developed. The time-varying parameter model I estimated has the following form:

$$R_t = \beta_{0,t} + \beta_{1,t}R_{t-1} + u_t, \qquad u_t \sim i.i.d.N(0,\sigma_u^2), \tag{4}$$

$$\beta_{m,t} = \beta_{m,t-1} + v_{m,t}, \qquad v_{m,t} \sim i.i.d.N(0,\sigma_{m,v}^2) \tag{5}$$

where $m = \{0,1\}$. Equation (4) is the empirical counterpart of Equation (3).[11] It stipulates that stock market returns are equal to a time-varying intercept, $\beta_{0,t}$, plus a time-varying slope coefficient, $\beta_{1,t}$, times lagged returns plus a stochastic

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[10] Because both the intercept coefficient and slope coefficient in Equation (3) are functions of the risk premium, it is reasonable to ask whether one should assume in the empirical model in Section 2.2 that these coefficients are correlated. The answer to this question depends on whether the risk premium changes over time.

[11] I used the Kalman-filter approach to estimate the model in Equations (4)–(5). Harvey (1992) and Kim and Nelson (2000) provide detailed descriptions of the Kalman-filter approach. I used Gauss 3.6 to implement the Kalman-filter approach, and I acknowledge use of computer programs described in Kim and Nelson (2000).

disturbance term. Equation (5) implies that the time-varying intercept and slope coefficients follow random-walk processes. Hence, the only source of variation in $\beta_{0,t}$ and $\beta_{1,t}$ is due to the variance of the respective stochastic disturbance terms, $v_{0,t}$ and $v_{1,t}$. The stochastic disturbance terms, u_t and $v_{m,t}$, are assumed to be independently normally distributed and are uncorrelated with each other ($E(u_t v_{m,t}) = 0$).[12]

3 Data

In order to study the predictability of returns, I used the monthly nominal stock market index compiled by Donner (1934). Donner's data start in 1870:1 and end in 1913:12. In order to obtain a real stock market index, I used the monthly cost-of-living data used by Gielen (1994, Chapter 8). The real stock market index I analyzed is identical to the index also analyzed by DeLong and Becht (1992) in their study of excess volatility of the German stock market before World War I.[13] A detailed description of the data can be found in their paper.

— Insert Figure 1 about here. —

In order to get the ball rolling, Panel A of Figure 1 graphs the real stock market index for the German stock market for the period 1880:1–1913:12. The figure begins in 1880 because, in my empirical analysis in Section 4, I will drop the 1870s from the sample. One reason for this is that Donner's index only covers a relatively small number of companies in the early 1870s.[14] Another reason is that exceptional bubble-like phenomena were characteristic of the German stock

[12] I also estimated a version of the model in which the error term in the return equation is conditionally heteroskedastic, but the estimation results turned out to be very similar to the estimation results I will report in Section 4.1 below.

[13] The only difference between their data and my data is that DeLong and Becht analyzed yearly data.

[14] The number of companies in Donner's index increased over time. The index covered seven companies in 1870, 13 companies in 1876, 51 companies in 1890, and 69 companies in 1913. Fur more details, see Donner (1934, page 96).

market in the early 1870s.[15] Yet another reason is that, a statistical point of view, beginning in 1870 the iterations required that I estimate my empirical model, but neglecting the 1870s when evaluating the log-likelihood function of the model minimizes the effect of the starting values of the models parameters on the estimation results. It should be noted, though, that the estimation results do not change much when one lets the sample period begin in, for example, 1876, as DeLong and Becht (1992) did.

— Insert Table 1 about here. —

Table 1 offers summary statistics of continuously compounded real returns.[16] The mean of returns is almost zero, the skewness of the unconditional returns distribution is slightly negative, and the unconditional returns distribution is leptokurtic, i.e., its kurtosis exceeds that of the normal distribution. Thus, the unconditional returns distribution has "fat tails." There is also evidence for a significantly positive first-order autocorrelation coefficient. The autocorrelation coefficients of orders larger than one are almost zero and are statistically not significant. There is also some evidence for autocorrelation in the squared returns. However, because I used monthly data, it is not surprising that the evidence for autocorrelation in squared returns is not overwhelmingly strong. All in all, Table 1 highlights that the summary statistics of real returns in nineteenth century Germany closely resemble the summary statistics and "stylized facts" of other historical and modern financial market data (Lux and Marchesi 2000; Goetzmann 1993; Harrison 1998).

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[15] See Henning (1996) for a detailed description of this crisis of the early 1870s (the so-called *Gründerkrise*).

[16] Summary statistics of nominal and excess returns (i.e., returns minus a risk-free interest rate (*Privatdiskont*; see Donner 1934)) are similar and are, therefore, not reported.

4. Results

In order to discuss my estimation results, I proceed in three steps. In a first step, I describe the results of estimating the time-varying parameter model described in Section 2.2 (Section 4.1). In a second step, I interpret my estimation results in the light of a then-contemporary report of stock market developments in nineteenth century Germany (Section 4.2). I will argue that my estimation results are consistent with the argument that the predictability of returns in the German stock market before World War I reflected the influence of futures trading on the spot market. In a third step, I discuss whether the evidence for predictability of stock returns could be due to factors other than feedback effects of futures market (Section 4.3).

4.1 Description of Estimation Results

Table 2 summarizes my estimation results. Estimation results suggest that the variance, $\sigma^2_{1,u}$, of the disturbance term in the equation that governs fluctuations in the slope coefficient, $\beta_{1,t}$, is statistically significantly different from zero. Because this coefficient captures the degree of first-order autocorrelation in stock returns, this result indicates that the predictability of stock returns was not constant over time.[17] The results given in Table 2 also indicate that the variance, $\sigma^2_{0,u}$, of the disturbance term in the equation that governs fluctuations in the intercept, $\beta_{0,t}$, of the returns equation is statistically insignificant. Thus, there is no evidence that the intercept changed over time. I will come back to this evidence on the intercept of the estimated returns equation in Section 4.2 below.

— Insert Table 2 about here. —

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[17] Because the sampling distribution of the parameters is nonstandard, care must be taken when conducting tests for significance. See Harvey (1989, page 236). If the point estimate of a parameter is zero, then the corresponding coefficient $\beta_{i,t}$ is a constant, and conventional statistical theory can be used to conduct tests for significance. If the point estimate of a parameter is nonzero, then the corresponding coefficient $\beta_{i,t}$ varies and its significance can be graphically analyzed (see Figure 1).

It is interesting to study the time path of the coefficient $\beta_{1,t}$. Specifically, it is interesting to study when this coefficient was statistically significant, and whether the significance of this coefficient is systematically linked to developments in the stock market. Given the discussion of feedback trading in Section 2.1, it is also interesting to study whether the coefficient $\beta_{1,t}$ was positive or negative for most of the time.

As shown in Panel B of Figure 1, the coefficient $\beta_{1,t}$ was positive for most of the time.[18] A major exception in this regard is the period 1886–1887. During this period, the coefficient $\beta_{1,t}$ was negative. Interestingly, during this period, a run-up of the stock market index began. Using the theoretical model outlined in Section 2.1, I conclude that the negative autocorrelation of returns during this period could indicate that positive feedback trading may have contributed to the run-up of the stock market index that began in 1887/1888.

— Insert Figure 1 about here. —

It is also evident from Panel B that, as the stock market index converged on its (local) maximum during the years 1889/1890, the sign of the coefficient $\beta_{1,t}$ changed significantly from negative to positive.[19] The coefficient $\beta_{1,t}$ became significantly positive after the stock market index had already reached its peak in

[18] When using the Kalman-filter approach, one can either use the filtered or the smoothed estimates of the models' coefficients to measure predictability of returns. The difference between the two lies in the information set one uses (Kim and Nelson 2000). Filtered estimates are based on information available up to period *t*. Smoothed estimates are based on all available information in the entire sample. I report filtered estimates because, in any given period *t*, a stock market participant can only use information up to time *t* for making inferences about time-varying predictability of returns.

[19] This significant change in the coefficient was confirmed by the results of a Chow test, recursively estimated over the sample period. The test result indicated significant instability of the slope coefficient in a regression of returns on lagged returns in the first half of 1888. This result also obtained when critical values were adjusted to account for the fact that the exact period of the break was unknown.

early 1890. Thereafter, a period of time of significant positive autocorrelation in stock returns began. This period of time continued while the stock market index was declining from early 1890 until late 1891, and only ended when the stock market index approached a trough in 1892.

From 1892 to 1900, the coefficient $\beta_{1,t}$ remained positive, and it was more or less constant and insignificant. Thus, in line with the theoretical model outlined in Section 2.1, it is possible that positive feedback trading may have contributed to the autocorrelation and, thus, the predictability of stock returns during the years 1890/1891, and that the extent of positive feedback trading was less significant from 1892 on.[20]

In 1900/1901, the coefficient $\beta_{1,t}$ increased when the large and substantial rise of stock prices that had begun in 1894 ended. As in 1890/1891, the coefficient $\beta_{1,t}$ remained significantly positive during the entire period during which the stock market index declined. From this it follows that, as in 1890/1891, negative feedback trading may have contributed to the predictability of returns during the downswing of the stock market index in 1900/1901. This period of significant positive autocorrelation of returns ended in 1902/1903 only after stock prices had begun increasing again. Thereafter, the coefficient $\beta_{1,t}$ remained positive, and it was more or less constant.

It is also interesting to note that a smaller change in the coefficient $\beta_{1,t}$ occurred in late 1907. During that time, a downswing of the stock market index that began in 1905 came to an end.

4.2 Futures Trading and Return Predictability: A Case Study

In order to understand the economics behind the results described in Section 4.1, it is useful to compare my estimation results with the reports of stock market

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[20] Wetzel (1996) has reported that the German Stock Exchange Law of 1896 had no effect on the informational efficiency of the German stock market. To this end, he has constructed a monthly stock market index for the period 1893-1899. It is interesting to note that the estimates of return predictability implied by my time-varying parameter model also show that returns were hardly predictable during this period.

developments documented by then-contemporary commentators on the German stock market. The book by Prion (1910) is particularly useful in this regard. Prion described the developments of the German stock market between 1888 and 1896 in detail.[21] Here, I will use his report to study the economics behind my estimation results. In doing this, I will focus on the period 1888–1892 because, as evidenced by Figure 1, this period seems to be particularly interesting for studying predictability and, thus, autocorrelation of returns. This period witnessed extended phases of negative (1888/1889) and positive (1890/1891) autocorrelation of returns. Thus, the period 1888–1892 can provide important insights into to whether feedback trading was an important source of autocorrelation in returns.

— Insert Figure 2 about here. —

Figure 2 shows the real stock market index, the estimated time-varying first-order autocorrelation of returns, and a number of economic and political events reported by Prion (1910). In the first months of 1888, the stock market index and the autocorrelation of returns began increasing. During these months, the autocorrelation of stock returns was negative. At that time, business cycle prospects were favorable and there was much liquidity "in the market." Also, because of favorable credit market conditions, it was relatively easy for bullish futures traders to finance their trading activities. According to Prion's reports, in June 1888, the upswing of the stock market gave rise to band-wagon effects and herding which implied that the upswing gained momentum. In September 1888, this upswing came to a temporary stop because the financial press and one of the German *Grossbanken* (large banks), the Deutsche Bank, publicly stated that the increase in the stock market was excessive. These statements, however, had only temporary effects on the stock market, and at the end of 1888 the stock market index began rising again.

The autocorrelation of returns began increasing during the second half of 1888. Maybe one reason for this is that the first months of 1889 were

[21] See also the reports of the Ältesten der Kaufmannschaft von Berlin (1888-1892).

characterized by discussions about whether business cycle prospects would stay favorable. Also, according to Prion, traders started unwinding their bullish positions. It is, therefore, not surprising that in spring 1889 massive strikes in the mining industry in the *Ruhrgebiet* and in *Oberschlesien* exerted a dampening effect on the stock market. In these months, it was not so clear whether investors would remain bullish, or whether the decline in stock prices indicated the beginning of an extended bearish phase. The bearish phase, however, did not last long because agents again started purchasing stocks. As a consequence of these purchases, traders in the futures market who had built up bearish positions also purchased stocks. The result was a further rise of the stock market index in summer 1889.

In December 1889, money-market conditions became tighter, making it more difficult to trade in the futures market. Also, uncertainty characterized stock market developments because professional traders were expecting a decrease of stock prices. As Prion reported, the large majority of other stock market participants, in contrast, hoped for a further increase in stock prices. These hopes for further increases in stock prices, however, did not materialize. The end of 1889 marked the beginning of a long phase of declining stock prices. It also marked the beginning of an extended period of significant positive autocorrelation of stock returns.

At the beginning of 1890, traders massively unwound their bullish positions, and this exerted a depressive effect on the stock market because the large majority of stock market participants were not willing to buy stocks. The ensuing decline in stock prices came to a temporary halt in February 1890 only because, as Prion reported, the Deutsche Bank intervened by purchasing stocks in an attempt to stabilize the market.[22] Hence, the Deutsche Bank conducted a “leaning against the wind” policy, i.e., a type of negative feedback-trading policy. Its intervention purchases were followed in August 1890 by purchases of traders in the futures

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[22] For a study of the role of the German *Grossbanken* for the stock market in Germany before World War I, see DeLong and Becht (1992).

market to cover there bearish positions. As can be seen in Figure 2, the result of these purchases was a temporary increase in stock prices.

Prion further reported that it was characteristic for the stock market situation in 1891 was that many traders had withdrawn from the market and that, as a consequence, the stock market was mainly populated by professional traders. These traders were engaged in massive futures trading on declining stock prices. This futures trading involved short sales of stocks. While stock prices continued declining, the traders in the futures market sought to cover their short positions by purchasing stocks in the spot market. Prion (page 139) reported that these purchases were an important determinant of stock prices in 1891.

I conclude that the behavior of traders in the futures market helps explaining why, as shown in Figure 2, the year 1891 did not witness a full-fledged stock market crash. Rather, stock prices declined over many months. I also conclude that, because it may have given rise to a kind of negative feedback trading, the behavior of traders in the futures market can be used to explain why the time-varying parameter model detects a significantly positive autocorrelation of returns in 1891.

4.3 Other Explanations for Predictability of Returns

Before jumping to definitive conclusions with regard to the link between short sales in the futures market, feedback trading in the spot market, and return predictability, it is worth studying whether explanations other than feedback trading may account for the magnitude of and time-pattern in the predictability and, thus, autocorrelation of returns described in Section 4.1.[23] For example, it could be the case that a time-varying risk premium helps explain autocorrelation of returns (for a discussion, see Cutler et al. 1991). Yet another explanation has been put forward by Lo and MacKinlay (1990) who have examined nonsynchronous trading as a source of autocorrelation of returns.[24] Moreover,

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[23] Not all of the results are reported, but are available from the author upon request.

[24] It must also be taken into account that using monthly averages of daily or weekly prices of the stocks introduces positive first-order autocorrelation into returns even if stock prices are a purely random sequence. See Working (1960) and Cowles (1960). It

Mech (1993) has found that transaction costs could help explain autocorrelation of returns. Finally, it is interesting to study to what extent my results are influenced by seasonal anomalies like, for example, month-of-the-year effects (Choudhry 2001).

4.3.1 Time-Varying Risk Premium

A natural question that arises is whether positive autocorrelation of returns is due to feedback trading, or whether a time-varying risk premium may have caused positive autocorrelation of returns. In order to study this question, I plot in Panel C of Figure 1 the conditional variance of the forecast error of predicted returns implied by my time-varying parameter model. Further, I plot in Panel D the coefficient $\beta_{0,t}$.

Panel C illustrates that the conditional variance of the forecast error increased during some, but not all, of the periods of time during which the coefficient $\beta_{1,t}$ was significantly positive and returns were, thus, predictable. For example, the conditional variance of the forecast error increased when the predictability of stock returns became significant in 1890 and in 1900. The question, therefore, is whether it is likely that the predictability of stock returns was merely due to changes in the premium paid for holding risky stocks.

To examine this question, it is useful to return to the theoretical analysis in Section 3.1. That analysis has shown that the potentially time-varying risk premium should show up in both the intercept and the slope coefficient of the time-varying parameter model: $\beta_{0,t} = \alpha_t + \mu_t$ and $\beta_{1,t} = -\gamma_t \mu_t$. Thus, if changes in the risk premium help explain changes in the slope coefficient, $\beta_{1,t}$, changes in the risk premium should also help explain changes in the intercept coefficient, $\beta_{0,t}$. Panel D shows that the intercept coefficient, $\beta_{0,t}$, is not significantly different from zero and hardly changes over time, even in those months in which

is not entirely clear to this reader whether Donner (1934) actually used averages of weekly or even daily data to construct his index, though the following quote suggests that he did not: "*Die Berechnung beginnt mit dem Jahr 1870 und ist für das Kurniveau und den Aktienmarkt monatlich durchgeführt.*" [Computations start in the year 1870 and are performed on a monthly basis for the level of stock prices and for the stock market.] (Donner 1934, page 96).

the conditional variance of the forecast error increased. This suggests that it is unlikely that a time-varying risk premium was the main source of return predictability in the German stock market before World War I.[25]

4.3.2 Nonsynchronous trading

The magnitude of the first-order autocorrelation coefficient in Panel B of Figure 1 suggests that it is unlikely that nonsynchronous trading can account for the predictability of returns. This follows from the theoretical results reported by Lo and MacKinlay (1990). They have derived the asymptotic autocorrelation of the returns of a well-diversified portfolio that consists of a large number of stocks. Each stock in the portfolio is not traded in any given period of time with a certain probability. A comparison of my empirical results shown in Figure 1 with the theoretical results derived by Lo and MacKinlay suggests that the first-order autocorrelation coefficient implied by my time-varying parameter model is way too large to be caused by nonsynchronous trading. Thus, I conclude that it is not very likely that non-synchronous trading was the main source of autocorrelation and, thus, predictability of monthly returns in the German stock market before World War I.

This conclusion is further corroborated by the fact that Donner's (1934) stock market index comprises a sample of Germany's largest companies. Furthermore, for the years 1892/1893, Gömmel (1992) has estimated the average daily turnover on the Berlin stock exchange, the most important stock exchange in Germany

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[25] Another possibility is that changes in the risk premium affect both the slope and the intercept of the regression equation, but the latter does not change because changes in μ_t are negatively correlated with changes in α_t. In order to check this possibility, I estimated a GARCH-in-mean model as in Sentana and Whadwani (1992). In their model, the coefficients in the return equation are defined as $\beta_{0,t} = \alpha_0 + \alpha_1 \mu_t$ and $\beta_{1,t} = -\gamma \mu_t$, where μ_t is given by the conditional variance of returns and the coefficient γ_t is assumed to be a linear function of the conditional variance of returns: $\gamma_t = \eta_0 + \eta_1 \mu_t$. The estimation results for this GARCH-in-mean model did not provide evidence for a GARCH-in-mean effect. Furthermore, aside from the coefficients in the GARCH equation, the only significant coefficient turned out to be the coefficient η_0 (with the expected positive sign).

before World War I, to be approximately 163 million Marks.[26] Of course, time-variation in participation in stock trading must certainly be taken into account.[27] However, Gömmel's estimate suggests that it is unlikely that the predictability of monthly returns during extended phases of a declining stock market was mainly due to nonsynchronous trading.

4.3.3 Transaction Costs

I used a model developed by Mech (1993) in order to study the effects of transaction costs on return predictability.[28] Mech's model is based on the insight that if transaction costs are an important source of predictability of returns, then stock prices should adjust rapidly to new information in periods when price changes are large relative to transaction costs. Based on this insight, he has developed a partial-adjustment model for stock prices. The main assumption on which this model is built is that, in each period, observed stock prices adjust partially to the time-varying "best" estimate of stock prices. An immediate consequence of this assumption is that observed returns are a weighted-average of lagged observed returns and the "true" returns of the best estimate of stock prices. The weighting factor is a function of the coefficient that describes the partial-adjustment of returns. This coefficient can change over time. Specifically, Mech has assumed that it is a function of the magnitude of absolute observed returns: The larger absolute observed returns are, the less important should be transaction costs, the faster stock prices should adjust, and, as a result, the larger the

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26 Gömmel has deduced his estimates from the total amount of tax revenues paid for stock market transaction in Berlin. If 60% of all transactions involved futures contracts, then, assuming 300 trading days per year and a yearly transaction volume of 49 billions Marks, the daily volume of spot transactions was on average 65 million Marsk and the transactions volume of futures contracts was on average 98 million Marks (Gömmel 1992, page 165-166).

27 See Section 4.2. For a study of changes in the turnover on German stock exchanges in the nineteenth century, see also Wetzel (1996, pages 232-239).

28 Taking into account the possibility that predictability of returns could be linked to transaction costs is interesting because stock market transactions were taxed in pre-World War I Germany. Interestingly, the main purpose of taxing stock market transactions was to raise tax revenues that could be used for financing military spending, not to throw a spammer in the works of capital markets. See Warschauer (1905) for a discussion.

adjustment coefficient should be. A larger adjustment coefficient, in turn, implies a faster and more complete adjustment of stock prices to new information, implying that predictability of returns should become insignificant.

Estimation of Mech's (1993) model requires the definition of a "best" estimate of the value of Donner's stock index. The choice of an instrument for this "best" estimate is not an easy task. Mech has used a large firm portfolio as an instrument in his analysis. This reflects his assumption that transaction costs should be smaller for large firms than for small firms. Unfortunately, Donner's data set does not cover separate data for small and large firms. Rather, Donner's data set only comprises data for an index of the largest German companies.[29] I, therefore, dropped the value of the "best" estimate of the index from Mech's regression equation and, thus, estimated a simplified version of his model.[30] As an alternative, I used the returns on the U.K. or the U.S. stock market index as an instrument for the returns on the "best" estimate of Donner's index.[31] In all estimated specifications of Mech's model, estimation results showed no evidence of a return-dependent adjustment coefficient. The coefficients were either insignificant or had the wrong signs. Hence, it is unlikely that transaction costs were a main source of the predictability of returns documented in Figure 1.

4.3.4 Month-of-the-Year Effects

Choudhry (2001) has found significant month-of-the-year effects in German stock market returns during the pre-World War I period. Hence, in order to assess the robustness of my results, I took month-of-the-year effects into account in my empirical analysis. In a first step, I regressed real returns on twelve monthly dummies. The estimation results of this regression confirmed Choudhry's result of significant month-of-the-year effects. In a second step, I saved the residuals from

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[29] Note that this implies that, if one buys the argument that transaction costs should be small for large firms, then transaction costs should play a minor role for the predictability of returns on Donner's index.

[30] In this simplified model, I regressed returns on a constant, lagged returns, and lagged returns multiplied by a dummy variable which was positive whenever absolute returns were larger than the median of absolute returns.

[31] I downloaded the data from the NBER Macroeconomic History internet page. For simplicity, I used nominal returns.

this regression and used them to reestimate my time-varying parameter model. Estimation results turned out to be very similar to the results summarized in Figure 1. In particular, the conclusions regarding the magnitude, sign, and significance of the coefficient $\beta_{1,t}$ were not affected by taking month-of-the-year effects into consideration.

5. Concluding Remarks

The empirical results documented in this paper suggest that the German stock market before World War I provides an interesting case study o the effect of feedback effects from futures trading on autocorrelation and, thus, the predictability of returns. Three main results emerge from my empirical results. First, the first-order autocorrelation coefficient was positive most of the time, albeit its significance changed over time. Second, autocorrelation of returns tended to be significant during extended periods of a declining stock market. Third, the time-pattern of autocorrelation can be explained in terms of potential feedback effects of futures trading on spot market dynamics.

This result is interesting in itself because it sheds new light on an old debate among economists in Germany a century ago. But, hopefully, the insights provided by the results I reported in this paper will also contribute to the debate on the causes and consequences of the financial globalization that we see in our modern times. This debate focuses, for example, on the costs and benefits of high international capital mobility. Further, it focuses on whether financial derivatives are the “beast” of modern finance that destabilize financial markets, whether financial transactions should be restricted, and whether a Tobin tax should be implemented. Studying the debate that took place in Germany in the nineteenth century reveals that many of these questions were already on the political agenda more than a century ago. Of course, the terminology used by economists and politicians at that time was different from the terminology we use today. But this does not imply that it is not worthwhile studying what we can learn from the arguments used by economists and researchers in pre-World-War-I-Germany, and from history itself.

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Table 1 — Summary statistics of real returns

Sample period	1880:1 – 1913:12
Mean	0.04
Median	0.00
Maximum	6.63
Minimum	-8.48
Standard Deviation	2.15
Skewness	-0.28
Kurtosis	4.05
AR(1)	0.19
AR(2)	-0.03
AR(3)	-0.03
AR(4)	-0.04
Q-statistic	15.11***
$LM-ARCH\,(1)$	4.65**
$LM-ARCH\,(2)$	4.22
Jarque-Bera test	24.17***

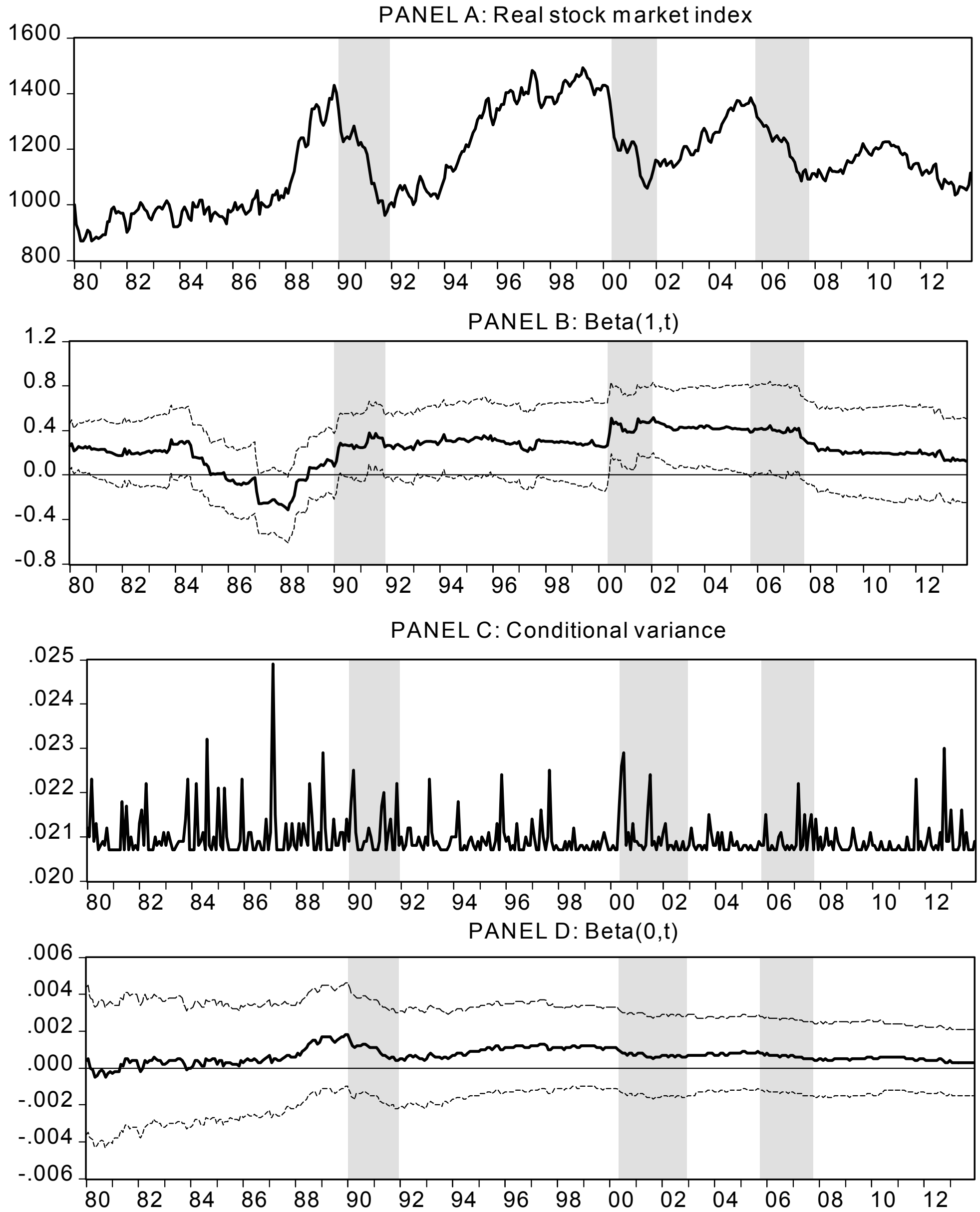
Note: *** (**) denotes signficance at the one (five) percent level. The table gives summary statistics of continuously compounded monthly real returns. Returns were computed as $R_t = 100 \times [\log(index_t) - \log(index_{t-1})]$, where $index_t$ denotes the real stock market index. *AR*(*i*), *i*=1,…,4 denote the coefficients of autocorrelation of order *i*. The *Q*-statistic denotes the Box-Lung statistic for autocorrelation of first-order. *LM-ARCH*(*i*) denotes Engle's (1982) Lagrange multiplier test for autocorrelation of order *i* in the squared returns. The Jarque-Bera test is a test for normality of the unconditional returns distribution.

Table 2 — Estimated parameters of the time-varying parameter model

Sample period	1880:1 – 1913:12		
Iterations		14	
Log likelihood function		998.04	
Parameters	σ^2_ε	$\sigma^2_{0,u}$	$\sigma^2_{1,u}$
Point estimate	0.021	<0.000	0.029
Standard deviation	0.001	0.001	0.016

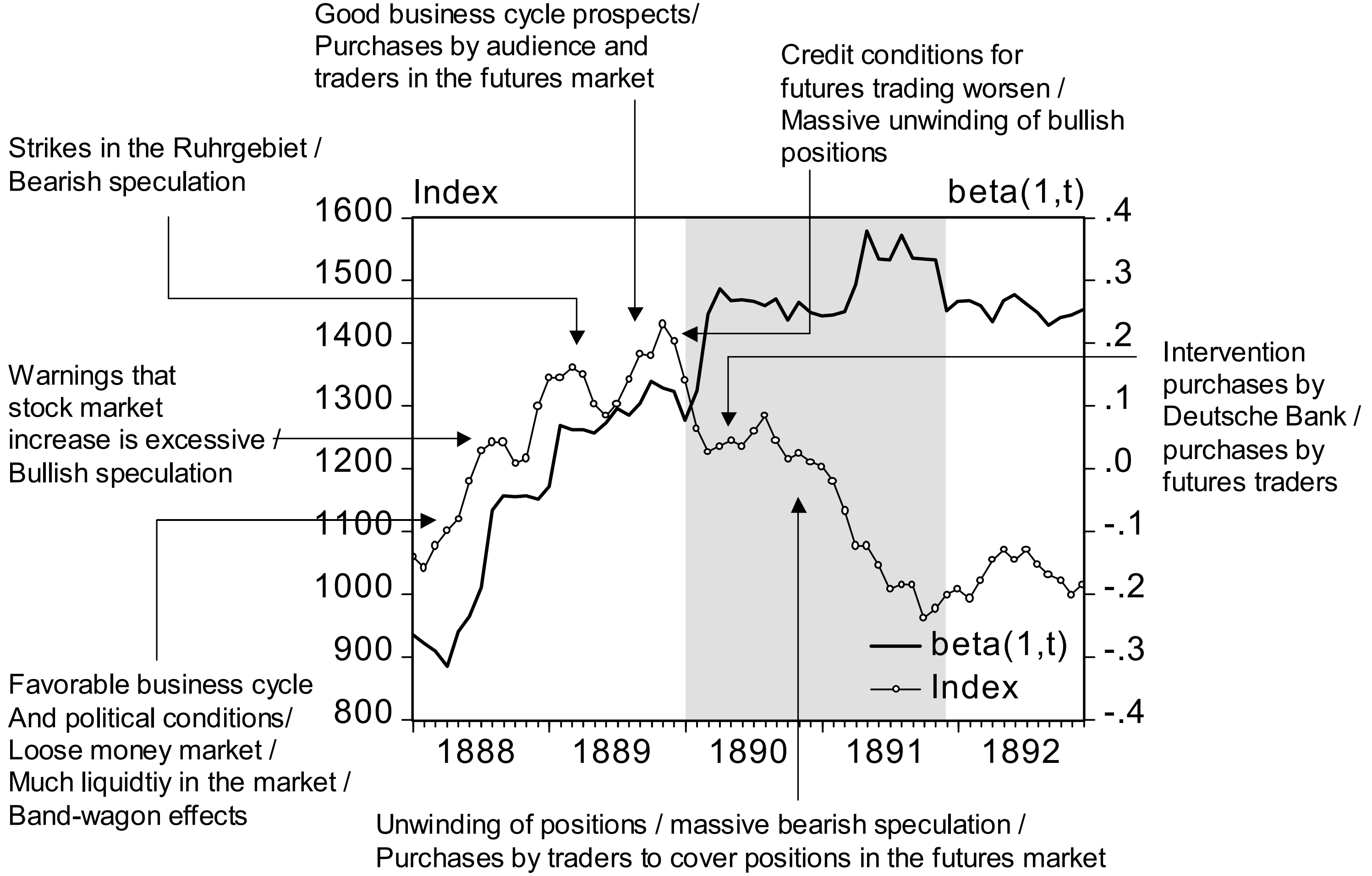
Note: The table reports the results of estimating the time-varying parameter model described in Section 2.2 by maximum likelihood.

Figure 1: Real stock market index and results of time-varying parameter model (1880:1 – 1913:12)



Note: Beta(0,t) denotes the coefficient $\beta_{0,t}$. Beta(1,t) denotes the coefficient $\beta_{1,t}$. The time paths of these coefficients are shown together with the corresponding confidence bands ($\pm 2 \times$ standard deviations). The coefficient $\beta_{1,t}$ captures the time-varying predictability of returns. Returns were computed as $R_t = 100 \times [\log(index_t) - \log(index_{t-1})]$, where $index_t$ denotes the real stock market index. Shaded areas highlight major phases of significant predictability of returns. Conditional variance denotes the conditional forecast error variance of predicted returns implied by the time-varying parameter model. The graph shows filtered estimates of $\beta_{0,t}$ and $\beta_{1,t}$. The shaded areas highlight extended periods of a declining stock market.

Figure 2: Real stock market index and time-varying return predictability (1888:1 – 1892:12)



Source: Own estimates and Prion (1910). The shaded area denotes an extended period of a declining stock market. This was also a period of significant predictability of returns.