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Information Transmission under Increasing Political Tension – Evidence for the Berlin Produce Exchange 1887-1896

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Abstract

This article studies the effects of increasing political uncertainty on the functioning of futures markets. For this purpose, we utilize a unique natural experiment, namely the discussions around and the final coming into force of the German Exchange Act of 1896. Using static and time-varying vector error correction models, the empirical analysis shows that, although early futures markets exhibit a high degree of operational efficiency, increasing political tensions were related to a declining dominance of the futures market in the price discovery process. In summary, we provide a strong illustration of the negative consequences of misplaced regulatory attempts caused by strong political interests.

JEL Classification: N23, N44, G14, G28, Q14, Q18

Keywords: Early commodity futures markets, Berlin Produce Exchange, Uncertainty, Price discovery, Regulation

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1 Motivation

In the aftermath of the boom-and-bust periods of commodity prices over the past 15 years, which followed a period of relatively stable prices, academics and policymakers renewed interest in the drivers of commodity price movements. In particular, the discussions have focused on the questions, whether commodity price fluctuations have been mostly driven by fundamental demand and supply forces and further whether they have been further aggravated by speculative activity in commodity futures markets. As a consequence, a ban of futures trading in commodities has been subject of public discussion for years.[1] However, public discussions are often carried out relatively indiscriminately, overlooking the fact that futures markets contribute significantly to the functioning of spot markets (Garbade and Silber, 1983). Since futures markets exhibit lower transaction costs, higher liquidity and greater transparency, they reflect new information faster than the spot market (Working, 1963; Black, 1976). In this context, an unresolved question is how the advantageous market mechanisms are affected if their continuing existence is threatened by overly ambitious regulatory and political attempts.

We aim to answer this question by focusing on a unique real world experiment from the 19th century, the German Exchange Act of 1896, and its effect on the information transmission process at the Berlin Produce Exchange, one of the dominant exchanges for commodity futures trading at that time.[2] The evolution of commodity futures trading in the middle of the 19th century has continously been accompanied by a significant public and political opposition (Jacks, 2007).[3] Consequently, numerous political initiatives attempted to impose

[1] E.g., on February 28, 2016, Switzerland held a unsuccessful referendum on banning speculation in agricultural commodities.

[2] A ban on commodity futures trading was only obtained twice in the history of financial markets to our knowledge. Namely, the ban on onion futures caused by the coming into force of the Onion Futures Act (e.g. Working, 1960) and the suspension of the Berlin Produce Exchange following the German Exchange Act in 1897. We focus on the German case, since th economic significance is of much higher magnitude.

[3] Commodity futures trading has been diametrically opposed to conventional social and religous norms and was always seen in line with gambling (Jacks, 2007).

a ban on commodity futures trading.[4] In 1891, the German agricultural interest parties initiated discussion about whether futures trading should be banned due to its destabilizing effect on the price formation of agricultural products. After protracted political debates, the German parliament ratified the German Exchange Act in 1896, which was applied to all exchanges in the German Empire and prohibited futures trading in grain and mill products.

In this paper, the question arises as to whether futures markets dominate the price discovery process in a similar manner as they do in modern financial markets and whether the possible dominance was influenced by the increased regulatory pressure associated with the German Exchange Act. Since the coming into force of the German Exchange Act was not an unexpected event and the discussions around it dragged on for several years, we are able to examine how increasing uncertainty about the continued existence of agricultural futures trading affected the functioning of the futures market.

Our analysis builds on recent findings in the price discovery literature. Previous studies show that the impact of informed trading on the evolution of efficient prices is not constant and may vary over time (Easly and O'Hara, 1992; Dufour and Engle, 2000). In particular, the number of market participants and the intensity with which market participants incorporate information in their trading behaviour affects the information transmission process (Admati and Pfleiderer, 1988; Back and Pedersen, 1998). Hence, price discovery dynamics may depend on trading volume, number of trades and investor structure (Chakravarty et al., 2004; Ates and Wang, 2005; Chen and Gau, 2009, 2010; Bohl et al., 2011). Moreover, price discovery may also depend on market liquidity and information asymmetry among market participants. In the event of an impending futures trading ban, market participants may reallocated their trading activity to foreign futures exchanges or to the OTC market, decreasing liquidity and the amount of information directly incoprorated through the domestic futures market.

So far, one of the main difficulties in the empirical analysis of early financial markets has been the availability of data. To overcome this limitation, we hand-collect a unique dataset

[4] See Jacks (2007) for a comprehensive overview of historic initiatives, which intended to enforce the prohibition of futures trading in commodities.

comprising both weekly wheat futures and spot time series for the period 1887 until 1896. In the empirical analysis we apply bivariate vector error correction models (VECMs) and compute three commonly applied measures to determine the relative contribution to price discovery. Since we are interested in structural changes in the price discovery process due to increasing political tension, we allow for time-variation in the price discovery measures by employing rolling-window estimations of the underlying VECMs and structural break tests.

The time-invariant specification reveals that on average early futures and spot markets exhibit time series characteristics comparable to more contemporary commodity time series. Inferences from the static VECM and price discovery measures indicate that futures markets dominate on average the information transmission process. The time-variiying approach reveals that the price discovery process was affected by rising political tension. The dominance of the futures market declines around major events of the political debate in the sample period, irrespective of the price discovery measure investigated. Structural break tests identify consistent break dates.

Our findings contribute to the literature in several distinct ways. We add to prior work investigating the basic functioning information transmission in the absence of modern trading institutions. Early commodity and security markets emerged in a relatively unregulated environment and trading institutions where established under disparate socio-economic preconditions (Gehrig and Fohlin, 2006). Therefore, trading institutions in the markets under scrutiny differ significantly and are characterized by continued adjustment to the requirements of their business location (Michie, 1986; Gehrig and Fohlin, 2006). Our evidence shows that, despite their low degree of regulation, early financial markets operated comparably to modern markets in terms of information transmission. Furthermore, we contribute to the literature analyzing the effect of regulatory attempts on the functioning of financial markets. We provide evidence that misplaced regulatory attempts caused by strong particular interests may negatively affect the functioning of financial markets and hence yield detrimental results.

The remainder of this paper is structured as follows: In Section 2, a detailed introduction into the functioning and emerging of early commodity futures markets as well as the implementation of the German Exchange Act are provided. The data presentation takes place in Section 3. This is followed by the introduction of the methodology used to investigate the impact of the discussion around and finally the implementation of the German exchange act on the price discovery process. The empirical application of the previously presented testing procedures takes place in Section 5. Finally, Section 6 concludes.

2 The Berlin Produce exchange and the German Exchange Act of 1896

Understanding the chronological sequence of events is crucial in understanding whether the increasing uncertainty about the continued existence of commodity futures trading affected the price discovery process. Futures trading in grain products (mainly wheat and rye) at the Berlin Produce Exchange emerged in the last thirty years of the 19th century (Jöhlinger, 1925), at a time period where exchanges for commodities or securities appeared across the globe. At that time, Berlin became the leading financial center and dominant trading place for commodities and securities in Germany (Hirschstein, 1931; Gehrig and Fohlin, 2006). Two historical events were mainly responsible for this developement. In 1866, the traditional German financial centre, namely Frankfurt, was occupied by Prussia while in 1871 Berlin became the capital following the unification of the German Empire. The role as an important trading place for grain products is favoured by Berlin's central location, providing a natural link between the main grain producing areas in the eastern parts of the German Empire and the import dependent regions in the west. In addition, most foreign investors used the Berlin exchange to enter the German grain market (Schliep, 1912; Pinner, 1914). As highlighted by Jöhlinger (1925) the Berlin Exchange was not only the dominant market in the German Empire, but also played an important role within the continental European grain trade, contributing significantly to informatopn transmission process on exchanges across Europe.

After the introduction of the German Exchange Act and thus, the suspension of the Berlin Produce Exchange, the inter- and national importance of Berlin as a leading exchange for grain products was significantly reduced (Schliep, 1912; Pinner, 1914). As highlighted by Pinner (1914), due to the absence of price quotations national market participants used quotations of foreign markets as substitute or shifted their trading activities directly to foreign exchanges, especially in North America. Therefore, after the introduction of the Exchange Act the Berlin Exchange lost significant amounts of business volume as well as its property as benchmark for the continental Europe grain trade (Schliep, 1912; Pinner, 1914; Jöhlinger, 1925).

As stated above, the German Exchange Act of 1896 caused considerable harm to the grain futures markets in the German Empire. Hence, for our analysis and to understand the reasons behind the decline of the Berlin Produce Exchange, it is crucial to illustrate the chronology of events leading to the Börsenenquetekommission and finally to the German Exchange Act.[5] The following chronology of events is mainly based on Schliep (1912) and is briefly summarized in Table 1.

[Table 1 about here]

The German agrarian sector was suffering from a severe crisis due to the depression in grain prices beginning in the end of the seventies of the 19th century and observers blamed futures trading, which emerged during the same time period, to be responsible for their misery (Lexis, 1897; Schliep, 1912; Jacks, 2007). Looking back, these arguments appear to be unjustified but nevertheless, early futures markets were largely unregulated and fraudulent behaviour or speculative bubbles seem to be observed regularly (e.g. Schliep, 1912). As highlighted by Lexis (1897), several private persons with no physical interest in the underlying good used futures for speculative purposes. Speculation in bonds and commodity markets was a

[5] A detailed overview of the Börsenenquetekommission, its composition, proceedings and chronology of events could be find in a variety of contemporaneous sources. For further reading we recommend Lexis (1897),Weber (1894), Hooker (1901), Schliep (1912) and Jacks (2007).

widespread activity among members of all social classes towards the end of the 19th century, resulting in a multitude of insolvencies and heavy financial losses across all layers of society. In 1891, the financial system of the German Empire was heavily impacted by the collapse of several important Banks, misappropriation of bank deposits and equity investments as well as unexpected and rapid changes in grain prices at the Berlin Produce Exchange (Schliep, 1912). In particular, the depression in 1891 caused severe losses among financial investors and prepared the ground for the German Exchange Act of 1896.

Accordingly, the main task for the commission of inquiry, appointed on the 6th of February 1892 by imperial chancellor Leo von Caprivi, was not to ban outright futures trading, but to impede market access for small non-commercial trader (Lexis, 1897). The commission (*Börsenenquetekommission*) was composed of representatives of commerce, industry, mining, banking as well as government officials, large landowners and legal scholars. Beginning at 6 April 1892 until 11 November 1893, the commission of inquiry conducted 93 non-public meetings and hearings with representatives of all parties concerned by the new exchange act, including representatives of grain trade, agricultural operations and the milling industry (Schliep, 1912).

The findings of the commission, along with a draft legislation, were officially submitted to the imperial chancellor at the 11 November 1893 and published in the imperial gazette. As highlighted by several contemporary sources (e.g. Lexis, 1897; Hooker, 1901; Schliep, 1912), a variety of problematic issues with respect to futures trading were identified and regulatory measures to hamper its negative aspects recommended, but there was no intention to prohibit trading in futures outright (Lexis, 1897; Schliep, 1912). The debate on a new exchange act was reopened on 19 April 1894, as the imperial parliament requested that the government provides a draft legislation based on the findings of the commission of inquiry. After the draft legislation was approved with minor amendments by the imperial council, it was submitted to the parliament on 3rd December 1895. The first reading took place from 9 to 11 January 1896. Afterwards, the draft legislation was discussed by a parliamentary subcommittee. During this discussion, the proposal legislation was substantially revised and the prohibition of trading in futures was proposed. Only with substantial efforts and significant concessions regarding a stronger regulation of futures contracts by governmental officials was the first attempt to prohibit futures trading averted. Nevertheless, during the second reading from 28 April to 1 May 1896, the concessions made proved to be insufficient. A proposal, introduced and supported by members of agrarian parties, renewed the demand for the prohibition of futures trading in grain and mill products. Without sufficient support of the imperial government, this proposal passed the parliament during the third reading of the draft legislation from 5 to 6 June 1896. In addition, claiming that commodity price quotations provided by the exchanges were deliberately falsified, the agrarian parties required that their representatives should be included into the fixing of price quotations (Schliep, 1912).

Surprisingly, this last legislative requirement led to the suspension of the Berlin Produce Exchange. The new exchange act enabled the governments of the federal states of the German Empire to oblige the inclusion of representatives of the agricultural sector into the executive boards of produce exchanges. On 11 July 1896, the Prussian Minister of trade, responsible for inter alia the supervision of the Berlin Produce Exchange, requested the publication of new rules of the exchange, which would satisfy the new legal requirements. Representatives of the Berlin exchange submitted the amended rules of the exchange on 23 September 1896, which did not satisfy the legal requirements. Although on 30 December 1896 a second set of rules was published, which was in line with the legal requirements, grain traders at the Berlin Exchange decided not to accept the imposed executive boards, due to the suggested hostile business interests of the agrarian representatives, and to meet outside the exchange. Therefore, when the Exchange Act came into force on January 1, 1897, the members had to cease official trading. Futures trading in grains in accordance with exchange methods was no longer permitted. Exchange methods included the public quotation of prices and fixing of a definite delivery time. Until 1900 futures trading remained banned. To avoid prosecution or to be forced to accept the requirements of the new exchange act, trading took place completely at the OTC market at a smaller scale. Due to the lack of publicly available and easily accessible information on prices etc., the majority of private and foreign investors left the market (Schliep, 1912).

3 Data

In order to investigate price discovery processes in early financial markets, and to evaluate whether they were affected by increasing political tension during the discussions leading to the German Exchange Act, we utilize closing prices for wheat futures and spot contracts traded at the Berlin Produce Exchange. The sample starts in January 1887 and ends in December 1896, which corresponds to the official prohibition of exchange-traded futures contracts on agricultural commodities.

Futures prices were hand-collected from the *Berliner Börsen Zeitung*, which was the leading financial daily in Germany of the pre-1913 period (Burhop and Gelman, 2011) and published daily price quotations for assets traded at the Berlin Exchange.[6] Generally, trading at the Berlin Produce Exchange took place six days per week except Sundays and holidays. Futures contracts were standardized: Prices were denominated in Reichsmark and in the case of wheat the contract size was defined at 1,000 kilogram of high quality wheat.[7] Until January 1894, the maturity date was defined over a bi-monthly time span (e.g. April/May). Afterwards futures contracts expired on a monthly basis.

Futures contracts with different maturity dates were traded simultaneously. As no information regarding the open interest and trading volume of futures contracts is available, we have to rely on a rolling criterion based on the maturity date for constructing a continuous futures price time series. More specifically, we construct a continuous futures price time se-

[6] The newspapers are available as PDF files on the website of the Staatsbibliothek zu Berlin. However, due to the specific text format and quality of PDFs it remains technically impossible to automate the data collection process.

[7] According to Hooker (1901) the underlying wheat needs to be of sound quality with a weight of not less than 755 grams per liter.

ries by considering only the most nearby contract and rolling to the next nearby contract on the first day of the maturity month. Before 1894, we roll over on the first day of the former month. Our rolling approach is justified by the fact that the exact expiration date in the maturity month is defined by the selling party in the futures contract. Further, the Berlin Produce Exchange was dominated by individual speculators who were mainly interested in short-term cash profits and not in physical delivery. As the physical delivery could occur from the first day of the maturity period onwards, the majority of traders will reallocate to the next nearby contract to avoid physically delivery. Therefore, the rolling criterion ensures that we do not miss relevant trading information by rolling over too early while guaranteeing that liquid contracts are used for the construction of the continuous series.

In contrast to futures prices, reliable quotations for spot prices cannot be obtained from the *Berliner Börsen Zeitung*, as they are only defined as a price range from low to high quality wheat. This price range is to imprecise for our intended application, a fact that was already criticized by contemporary authors (e.g. Weber, 1894). Therefore, we rely on daily spot price data gathered from the *Vierteljahrsheft zur Statistik des Deutschen Reichs* and *Reichsanzeiger*, which report daily spot prices for wheat traded at the Berlin Produce Exchange. The corresponding prices are quoted in Reichsmark for purchase of 1,000 kilogram of delivery quality wheat, consistent with the quotation for wheat futures prices.

We compute the natural logarithms of the wheat spot and futures prices as $s_t = log(S_t)$ and $f_t = log(F_t)$. Continuously compounded daily returns are derived by $\Delta s_t = (s_t - s_{t-1})$ and $\Delta f_t = (f_t - f_{t-1})$. However, for the wheat market under consideration, nearly 51% of daily returns in the spot market are equal to zero while for the futures market the share is close to 9.5%. The influence of zero returns can be problematic in the context of econometric estimations in case long sequences of observations are zero. Therefore, we reduce the sampling frequency to weekly data, decreasing the share of zero-returns to 17.8 % and 4.8%, respectively. Weekly data are obtained by utilizing price quotations on Wednesdays, since we observe the least number of holidays and therefore missing values in our samples on Wednesdays. In case the Wednesday observation is missing, price quotations of the next nearby trading day are used. Table 2 displays summary statistics of weekly price and return time series for the futures and spot market. ZR indicates the percentage of zero return obervations. In general, we observe compareable distributional characteristics for the weekly price and return time series in spot and futures markets.

[Table 2 about here]

Figure 1 illustrates the evolution of both future and spot prices over the entire sample period from January 1887 until December 1896. The illustrated price dynamics indicate significant co-movement between both time series, with a minor exception in mid 1890 and 1891. The deviations may be due to market turbulence during the financial crisis caused by the default of the Baring Brothers Bank. Overall, the price time series display spikes and crashes between 1891 and 1893 followed by a period of relatively low prices.

[Figure 1 about here]

4 Methodology

The economic literature indicates that spot and futures prices are related through arbitrage opportunities between the two market segments. The theory of storage, initially proposed by Kaldor (1939), states that a cointegration relationship exists for the logarithms of futures prices, f_t, and spot prices, s_t, for the same underlying commodity. From a market microstructure perspective, the long-run relationship may exist because both spot prices and futures prices may depend on the common fundamental price of the underlying commodity. The so-called cost-of-carry relationship can be formulated as follows:

$$f_t = \beta_0 + \beta_1 s_t + ec_t, \tag{1}$$

where β_0 denotes the constant coefficient, which captures the cost-of-carry. The cost-of-carry rate reflects the cost of storage, opportunity cost of capital (foregone investment return or financing cost) as well as the convenience yield, which captures the uncertainty of future supply and demand conditions in the respective commodity market. Thus, variations in β_0 can explain the occurrence of backwardation or contango. A different interpretation of the constant coefficient is suggested by the normal backwardation (Keynes, 1930) and hedging pressure (Cootner, 1960; Deaves and Krinsky, 1995) theories. This strand of the literature proposes that the spot and futures price differntial reflects the difference between market participants' expectations of the variation of spot prices and a risk premium. β_1 is the slope coefficient. The unbiasedness hypothesis (Brenner and Kroner, 1995; Engel, 1996) implies that the futures price with maturity T-t is an unbiased predictor of the future spot price in T assuming risk neutral agents with rational expectations. In the context of Equation 1, the unbiasedness hypothesis presupposes β_1 to be equal to one yielding a cointegrating vector of (1 -1). The error correction term ec_t captures short-term deviations from the long-run cost-of-carry equilibrium relationship. Brenner and Kroner (1995) suggest that market participants will exploit any deviations from the equilibrium relationship by implementing suitable trading until they are indifferent between (1) purchasing the commodity today in the spot market and holding it while incurring storage costs and earning the convenience yield and (2) purchasing a portfolio consisting of a risk-free zero-bond and the respective future contract. Short-term deviations may occur due to market frictions, which temporarily limit arbitrage activities. Apart from general market frictions, such as limited information processing capacities or transaction costs, commodity investors face specific frictions related to production, transport and storing commodities (Spulber, 1996). To ensure a cointegrating relationship between spot and futures markets, the error correction term has to be stationary and hence must not contain a stochastic trend.

We apply the ADF test of Dickey and Fuller (1979, 1981) and the KPSS test of Kwiatkowski et al. (1992) in order to test whether both time series are integrated of order one. We apply both testing procedures because the null hypotheses are reversed: In contrast to the ADF test, which presumes a unit-root in the null, the KPSS test assumes a unit root in the alternative hypothesis. The joint application of both unit root tests is also referred to as confirmatory data analysis and yields robust results with respect to the presence (absence) of a unit root (Brooks, 2011). Both testing procedures are applied by including a constant in the test equations. However, ADF and KPSS tests assume no structural break in the time series. Therefore, we also conduct a sequential unit root test procedure proposed by Zivot and Andrews (1992), which estimates breakpoints endogenously. The Zivot and Andrews (1992) test permits a single break in the intercept (Model A), in the slope of the trend (Model B) and the hybrid of Model A and B (Model C).

Next, we follow the procedure suggested by Engle and Granger (1987) and Johansen (1988, 1991) to examine whether both time series share a common stochastic trend and a cointegrating relationship holds for spot and futures prices. According to Engle and Granger (1987) and Johansen (1991) the two time series have a bivariate VECM representation if the two time series are cointegrated. Thus, we are able to analyse short- and long-run dynamics of the price dynamics. We estimate the following bivariate VECM specifications:

$$\Delta s_t = \mu_{s,0} + \alpha_s ec_{t-1} + \sum_{i=1}^{p} \delta_{ss,i} \Delta s_{t-i} + \sum_{j=1}^{q} \delta_{sf,j} \Delta f_{t-j} + \varepsilon_{s,t} \tag{2a}$$

$$\Delta f_t = \mu_{f,0} + \alpha_f ec_{t-1} + \sum_{i=1}^{p} \delta_{fs,i} \Delta s_{t-i} + \sum_{j=1}^{q} \delta_{ff,j} \Delta f_{t-j} + \varepsilon_{f,t}, \tag{2b}$$

where $\mu_{s,0}$ and $\mu_{f,0}$ are the intercepts. $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$ correspond to the error terms, which are assumed to have zero mean and a covariance matrix $\mathbf{\Omega}$. Furthermore, we assume that the error terms are serially uncorrelated. The error correction term ec_{t-1} denotes the residual from the cointegrating relationship lagged by one period, such that $ec_{t-1} = f_{t-1} - \beta_0 - \beta_1 s_{t-1}$. α_s and α_f are the error correction parameters, which quantify how fast the respective market adjusts towards the equilibrium after short-run deviations. If, for example, the price in the spot market is above its equilibrium value, the futures price may increase/spot price may decrease to correct for the deviation from the cost-of-carry relationship.

Lastly, the coefficients $\delta_{ss,i}$, $\delta_{sf,j}$, $\delta_{fs,i}$ and $\delta_{ff,j}$ indicate the short-run dynamics of the VECM. Furthermore, the number of lags of first-differenced prices, which are considered in the system, is indicated by p and q. We obtain the optimal number of lags by using the Schwarz (1978) Bayesian Information Criterion.

In an initial step, we investigate the average information transmission process in our sample period to generally asses the quality and efficiency of the price discovery process in early financial markets. Thus, we utilize different price discovery measures to identify the relative contributions to the price discovery process. The considered measures rely on different statistical concepts and hence, estimation results and inferences need not be the same.

The component share (CS) builds on the common factor weights concept (Gonzalo and Granger, 1995; Schwarz and Szakmary, 1994). The CS measures the individual absolute magnitude of the error-correction adjustment parameter in the VECM relative to the total adjustment to quantify the relative contribution of each segment. We calculate the CS for the futures (θ_f) and the spot market (θ_s) as follows:

$$\theta_f = \frac{|\alpha_s|}{|\alpha_s| + |\alpha_f|} \quad \text{and} \quad \theta_s = 1 - \theta_f = \frac{|\alpha_f|}{|\alpha_s| + |\alpha_f|}. \tag{3}$$

By construction, the component share is limited to values between zero and one. The market segment with the highest error correction coefficient accounts predominantly for adjustments to deviations from the long-term equilibrium. If for instance $|\alpha_s| > |\alpha_f|$ and thus $\theta_f > 0.5$, price discovery happens mainly in the futures market. Apart from the intuitive interpretation the CS has additional desirable properties. The CS is unique and allows for testing the statistical significance of a market's contribution to price discovery (Lien and Shrestha, 2009). However, it ignores the innovation variance.

A different price discovery measure, commonly referred to as the information share (IS), was proposed by Hasbrouck (1995). For each market, the IS reflects its share of total equilibrium price variance that can be attributed to it. The IS of market i can be computed as:

$$IS_i = \frac{([\boldsymbol{\Psi F}]_i)^2}{\boldsymbol{\Psi \Omega \Psi'}}, \quad i = 1, 2, \tag{4}$$

where $\boldsymbol{\Psi\Omega\Psi'}$ represents the equilibrium price variance and $\boldsymbol{F}$ the Cholesky decomposition of the estimated VECM error covariance matrix $\boldsymbol{\Omega}$. $\boldsymbol{\Psi}$ denotes a matrix capturing the long-run impact. Similar to the CS, the IS is bounded by the interval between zero and one and price discovery occurs mostly in the market with the higher IS. The concept of the IS has some attractive properties. It considers both the VECM innovations and their variances and complies with financial theory in the sense that prices are martingales (Lien and Shrestha, 2009). However, the IS has one considerable drawback. Since the Choleski decomposition relies on the ordering of the series, it does not provide a unique measure but instead an upper and lower boundary. In our analysis we use the midpoint between upper and lower boundary. Inferences about the relative contribution to the price discovery process are difficult, in case the two boundaries deviate significantly, which occurs if the two markets are highly correlated. According to Baillie et al. (2002) IS and CS yield consistent results, in case the estimated residuals of the bivariate VECM are uncorrelated.

Our third measure, the modified information share (MIS), which was initially proposed by Lien and Shrestha (2009), overcomes the ordering issue of the IS. The MIS can be computed as follows:

$$MIS_j = \frac{([\boldsymbol{F}^*\boldsymbol{\Psi}]_j)^2}{\boldsymbol{\Psi \Omega \Psi'}}, \quad j = 1, 2, \tag{5}$$

where an eigendecomposition of the estimated VECM error covariance matrix $\boldsymbol{\Omega}$ is employed to derive the matrix $\boldsymbol{F^*}$. The MIS can be interpreted in a similar way to the IS and CS. A value larger than 0.5 indicates that the corresponding market predominantly contributes to the price discovery process. The concept underlying the computation of the IS and MIS is closely related. However, both price discovery measures may lead to different results due to the variety of ways to factorize the estimated VECM error covariance matrix $\boldsymbol{\Omega}$. Unfortunately, the factorization approach of the MIS lacks any economic rationale (Grammig and Peter, 2013).

The foregoing price discovery measures are frequently employed in the literature. Unfortunately, they merely suggest which market segment on average predominantly accounts for adjustments to deviations from the long-run equilibrium. Hence, they are not suitable for identifying variations in the information transmission process over time.

In order to analyze time variation in price discovery we propose a rolling window-based estimation of the time-varying VECM (TV-VECM). Based on the time varying error correction coefficients and covariance matrix estimates, we are able to compute the corresponding rolling price discovery measures for each point in time starting at the end of the predefined initial sample window. For instance, we may choose an initial sample length of 156 weeks (approximately 3 years). Moreover, our sample period starts in January 1890 and ends in December 1896. In this example, we estimate the initial TV-VECM over the period 1st week January 1890 to 1st week January 1893. We then re-estimate the ECM over 156 weeks using a rolling window approach. The following TV-VECM is estimated over the period 2nd week January 1890 to 2nd week January 1893 and so on.

Concerning the rolling-window estimation, we face the problem associated with the optimal window length, since the literature lacks any statistical criterion to choose the window size. While too narrow windows may potentially cause very erratic patterns in the coefficient estimates, extremely wide windows can lead to little variations in the parameter estimates over the sample period. We balance the advantages and disadvantages and propose a window length of 104 weeks (approximately 2 calendar years).

In order to identify and test for structural breaks, we utilize the test method suggested by Bai and Perron (1998, 2003), which simultaneously estimates multiple breaks of unknown timing in univariate regression models relying on a dynamic-programming algorithm for stationary data[8] Further, the test assumes that in the absence of structural changes the level

[8] The Bai and Perron (1998, 2003) test employs a sequential procedure that searches for all possible sets of break dates. Next, the algorithm identifies for each number of possible breaks the set of structural breaks that maximize goodness-of-fit. Lastly, the test algorithm examines whether allowing for an additional structural break increases significantly the goodness-of-fit.

of a price discovery measure oscillates around a stable mean. In the context of this paper, the test will indicate a structural break in case increasing political tensions shift (long-lasting) the long-run mean toward a different level. The confidence intervals for the breakpoints are based on the distribution function proposed by Bai (1997). Furthermore, we apply 15% symmetric trimming and specify a maximum number of breaks of five.

5 Results

A necessary condition for a cointegrating relationship between spot and futures prices is that the time series are stationary in first differences. To test for stationarity in first differences, we first conduct ADF and KPSS unit-root tests. The empirical results are reported in Panel A of Table 3. The tests reveal that futures and spot prices are stationary at the 1% significance level by using log first differences. The Zivot and Andrews (1992) test confirms that spot and futures time series are stationary in first differences, regardless of the assumed structural break type. Once we establish that futures and spot prices are stationary in log first differences we then test whether the two time series are cointegrated. The Johansen trace and eigenvalue tests, reported in Panel B of Table 3, indicate the existence of one cointegrating relationship between futures and spot price time series.

[Table 3 about here]

Overall, the cointegration analysis yields robust evidence that the wheat futures and spot markets at the Berlin Produce Exchange were connected through a long-term equilibrium relationship, which is suggested by the cost-of-carry relationship and the majority of the price discovery literature for modern commodity markets. Thus, one may infer that futures and spot price time series exhibit similar characteristics to their modern counterparts.

The presence of cointegration between both time series enables us to examine the information transmission process by estimating a bivariate VECM, both of the static and time-varying variety. The time-invariant VECM results, displayed in Table 4 Panel A, indicate that the futures market dominates the information transmission process. The parameter α denotes the adjustment speed to deviations from the long-term equilibrium relationship, whereas δ_s and δ_f capture the short-run dynamics. The spot market adjustment factor α_s is statistically significant, while the future market parameter α_f is not statistically significant at any conventional level. The sign of the spot market coefficient is positive indicating that spot prices adjust downward (upward) if futures prices are below (above) the equilibrium price. The futures market dominates the information transmission process in that only the spot market reacts to movements in the efficent price.

[Table 4 about here]

Subsequently, the relative contribution to the information transmission process is examined. The estimated results for the three considered price discovery measures are illustrated in Panel C of Table 4. CS denotes the Schwarz and Szakmary (1994) and Gonzalo and Granger (1995) component share and IS is the Hasbrouck (1995) information share. The MIS proposed by Lien and Shrestha (2009) yields results that are comparatively homogeneous across all price discovery measures used. Each measure indicates that the futures market assumes a dominant role in the information transmission process with a compareable magnitude of dominance. CS, IS and MIS suggest an average price discovery contribution of the futures market over the entire sample period of 73%, 79%, and 74%, respectively.

In summary, the empirical evidence from the static parameter approach shows that early commodity futures markets were not inferior to their modern counterparts in terms of operational efficiency. It seems that futures prices were already in the late 19th century a trustworthy element of the information transmission process, despite the lower degree of market regulation and the speculative environment.

[Figure 2 about here]

Figure 2 illustrates the time-varying price discovery measures and the results of the structural break tests. The bold line represents the point estimate of the time-varying price discovery measures for the futures market. Due to the rolling-window regression procedure, the sample is restricted to the period January 1889 to December 1896.

Irrespective of the price discovery measure considered, we observe that the relative contribution of the futures market to the information transmission process is subject to considerable fluctuations. It drops from nearly 100% in January 1889 to below 20% in late October 1889. The spot market remains dominant (i.e. the relative contribution of the futures market remains below 50%) in the price discovery process until early 1891. A reason for this pronounced decline may be the bankruptcy Baring Brothers which led to a collapse of the financial system in Germany and a severe financial crisis across the globe. In the aftermath, the price discovery measures recover from the 1890 crisis and reach their peak level in the sample period of over 0.9 in July 1891. In mid 1893, we observe for each measure a sudden decline. The bust is most significant for the CS, with a decline to roughly 0.2. IS and MIS decrease to 0.4 and 0.3, respectively. Subsequently, the price discovery measures recover to previous levels. In the following years, which are characterized by increasing political pressure to abandon trading grains on futures delivery, the relative contribution to price discovery of the futures market varies sharply. We observe an increased volatility in each price discovery measure. In mid 1895, the futures market looses its dominance in processing new information, with a relative price discovery contribution below 50%, irrespective of the price discovery measure. In the last weeks of 1896, we observe across all measures a puzzling return to dominance by the futures market.

[Table 5 about here]

To further substantiate our analysis we also assess whether the time series of the different information measures display salient breaks during the period of increasing political tensions. In this regard, we employ the Bai and Perron (1998, 2003) test technique for multiple unknown breakpoints in the time series. Table 5 presents for each price disvovery measure the results of the Bai and Perron (1998, 2003) test. The empirical evidence is robust across the different measures. The $\text{SupF}_T(1)$, $\text{SupF}_T(2)$, $\text{SupF}_T(3)$, $\text{SupF}_T(4)$, $\text{SupF}_T(5)$ and UDmax are all statistically significant. The subsequent sequential test identifies a maximum of three structural shifts in the price discovery measure time series mean. In addition, Table 5 reports the estimated structural break dates as well as the corresponding 95% confidence interval boundaries. The break test identifies structural breaks in 1891 and 1895 across the different measures. Furthermore, the confidence intervals are narrow. The first structural break date coincides with a recovery from the financial market turbulence around the Baring Brothers bank collapse. The 1895 break may be interpreted in terms of increasing political tensions which intensified in 1895 when parliament discussed matters related to potential futures market regulation and draft legislation was prepared under significant influence of the hostile agrarian parties in the parliament.

The estimated intermediate second structural break differs however, depending on the price discovery measure. CS and MIS show a structural break in the beginning of 1893 while the mean of IS breaks in mid 1892. Further, the associated confidence interval is relatively wide for the MIS. The second structural break may denote increasing uncertainty around the final report of the commission as well as the associated legislative proposal. Since the bust in mid 1893 is less sudden and severe when the IS measure is used, it indicates the break in the mean much earlier than CS and MIS. However, the second break occurs across all measures during the commision period and is associated with a decline in the mean, indicating that even the commision period harmed the functioning of futures markets.

Overall, the time-varying analysis reveals that the dominance of the futures market in price discovery fluctuates considerably over time with significant structural breaks in the mean. The estimated break dates comply with the onset of a financial crisis and critical events during the period of increasing political antipathy towards future trading.

6 Conclusion

The pronounced spikes and crashes in commodity prices during the last decade caused a heated debate about the legitimacy of trading in commodity futures, culminating in demands for the total ban of commodity futures trading and, more recently, a referendum in Switzerland. The suspension of the Berlin Produce Exchange and the discussion around the German Exchange Act of 1896 provide us with a unique real world experiment on the impact of the prohibition of futures markets. By analysing this historical event, we contribute to the ongoing debate on futures market regulation.

The results indicate that futures markets of the 19th century exhibit return characteristics similar to modern futures markets. Futures and spot prices are stationary in differences and cointegrated. The analysis of a bivariate VECM and several price discovery measures indicates that futures markets played on average a dominant role in the price discovery process, despite the increasing political tension towards futures trading. This may be interpreted as evidence for the minor relevance of the modern regulatory and supervisory framework for the functioning of the information transmission process in commodity markets. The resulting inference is especially interesting from a regulatory point of view, as in the past years debates about agricultural commodity markets were always accompanied by the claim to ban or at least regulate futures trading more strictly.

The time-varying approach sheds more light on the robustness of the price discovery process towards increasing political tension. The price discovery measures fluctuate significantly during the period of political debates in the period from 1892 to 1896. The observed loss in futures trading dominance in terms of price discovery is mainly associated with the commision of inquiry in 1892/93 and the debates in parliament in 1895. Further, the Bai and Perron (1998, 2003) test indetifies break dates consistent with major events. These results imply that the political debates significantly harmed the price discovery process in a way such that the futures market's functioning was affected. It is conceivable that market participants reallocated their trading activity to either foreign commodity markets or to other speculative market segments, depending on the nature of the transaction.

Our results have important policy implications: First, by examining the suspension of the Berlin Produce Exchange, we provide a strong example of the negative implications of misplaced regulatory attempts caused by strong particular interests. Second, our results show that even in early financial markets futures played an important role in the transmission of information. Finally, this paper shows that historical financial markets deserve more attention as they provide the unique opportunity to learn from past successes and to avoid mistakes already made.

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Table 1: Chronology of events leading to the Berlin Exchange Act of 1896

Year	Month	Day	Event
1891			Disastrous banking failures in Berlin involving excessive speculation and fraudulent treatment of clients. Resolution for the establishment of a commission of inquiry.
1892	February	6	Commision of inquiry appointed by imperial chancellor Graf Leo von Caprivi and entrusted with a consideration of the whole subject of the exchange.
1892	April	6	First meeting of the commission.
1893	November	11	After 93 meetings, report of the commission as well as legislative proposal is submitted to the imperial chancellor and published in the imperial gazette. Commission recognized importance of trading for future delivery as a necessary instrument in modern commercial activity.
1895	December	3	After small amendments Federal council (*Bundesrat*) passed law to the imperial parliament(*Reichstag*).
1896	January	9-11	First reading and subsequent transfer to a subcommittee of the parliament. Subcommittee is toughening the initial draft law.
1896	April/May		During second reading from 28 April to 01 May request for the complete prohibition of futures trading in grain and mill products.
1896	June	5-6	Third reading and passage of the bill with 200 to 32 votes.
1896	June	22	Ratification of the law.
1897	January	1	Suspension of the Berlin Produce Exchange.

Notes: For a detailed description of the events see for example Schliep (1912) or Jacks (2007).

Table 2: Descriptive Statistics

	# obs.	% ZR	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis
Spot prices	522		5.13	5.51	4.82	0.16	0.33	-0.71
Futures prices	522		5.13	5.48	4.84	0.15	0.25	-0.84
Spot returns	521	0.179	0.000	0.084	-0.090	0.019	-0.179	4.143
Futures returns	521	0.048	0.000	0.134	-0.075	0.021	0.711	4.556

Notes: The table reports descriptive statistics for wheat spot and futures prices and returns. All prices are in natural logarithms and returns are the first differences of log prices denoted in percentage points. The sample period is January 03, 1887 to December 31, 1896.

Figure 1: Spot and Futures Prices (Weekly)

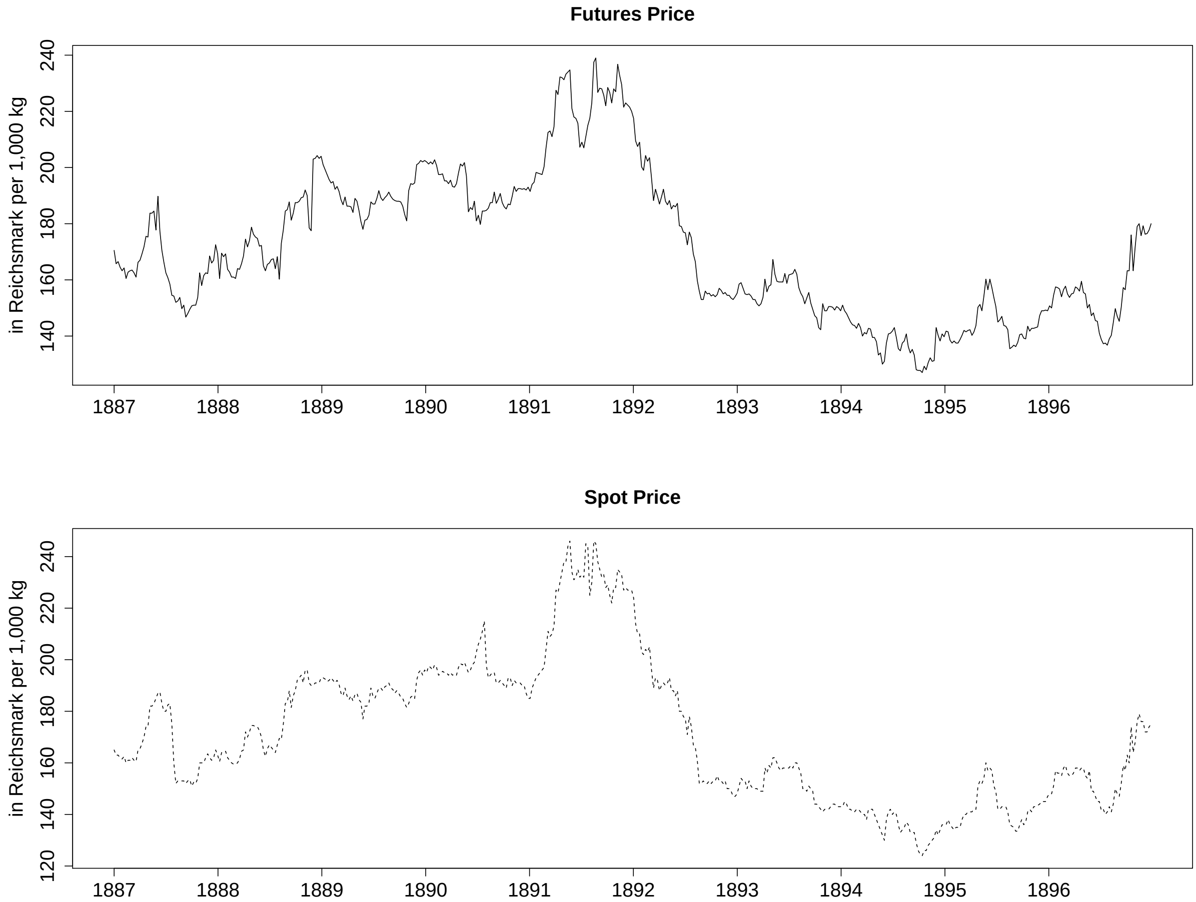


Table 3: Unit Root and Cointegration Analysis

	Panel A: Unit Root Tests				
			ZA		
	ADF	KPSS	A	B	C
Levels					
Spot	-1.433	1.233***	-3.846	-1.877	-3.315
Futures	-1.529	1.263***	-3.755	-2.159	-3.382
Returns					
Spot	-15.593***	0.108	-21.666***	-21.380***	-21.708***
Futures	-16.139***	0.098	-24.409***	-24.219***	-24.463***

Panel B: Johansen Test		
H_0: r = r_0	Trace	Eigenvalue
$r_0 = 0$	42.79***	40.70***
$r_0 = 1$	2.09	2.09

Notes: Panel A reports results of conducting the ADF and KPSS test on the log-levels and -returns of the sample data. Each test equation includes a constant and no linear trend. ZA denotes the Zivot and Andrews (1992) test with an endogenously determined breakpoint. A, B, C denote model types and correspond to the three different specification of the Zivot and Andrews (1992) test. Panel B shows the results of the Johansen trace and eigenvalue test, where r denotes the cointegrating rank (i.e., the number of cointegrating relationships) between the corresponding time series. Critical values are taken from MacKinnon et al. (1999). *, **, *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Table 4: Static Estimation Approach

	Panel A: VECM Adjustment Coefficients		
	α	δ_s	δ_f
Spot	0.1157***	0.0023	0.0770
Futures	-0.0413	0.0076	-0.0404

	Panel B: Price Discovery Measures		
	CS	IS	MIS
Spot	0.275	0.212	0.263
Futures	0.725	0.788	0.737

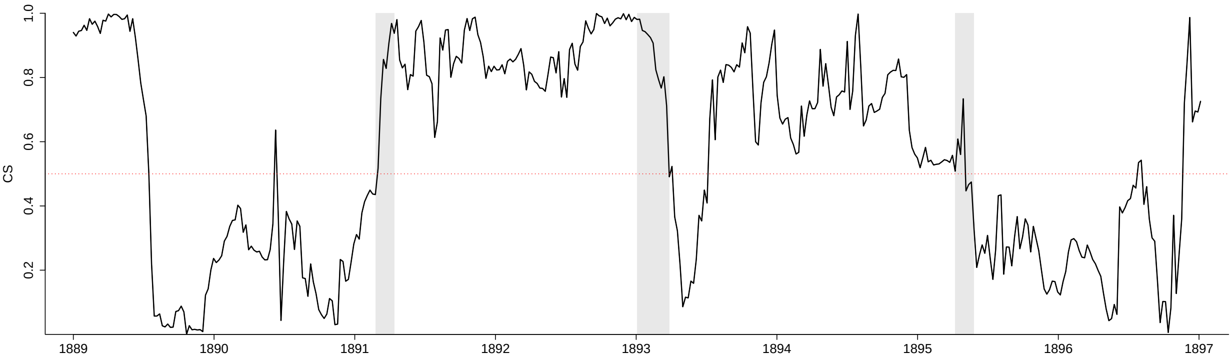
Notes: Panel A reports the estimated adjustment coefficients obtained from the bivariate VECM over the entire sample period from January 1887 to December 1896. Panel B shows the estimated values for the three considered price discovery measures. The reported value for the IS is the mean of the upper and lower bound. *, **, *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

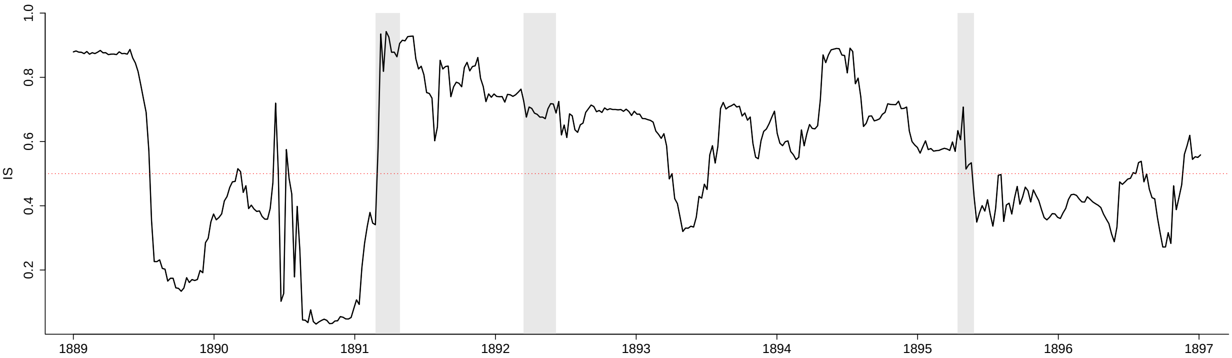
Table 5: Bai and Perron (1998, 2003) Test of multiple Structural Breaks

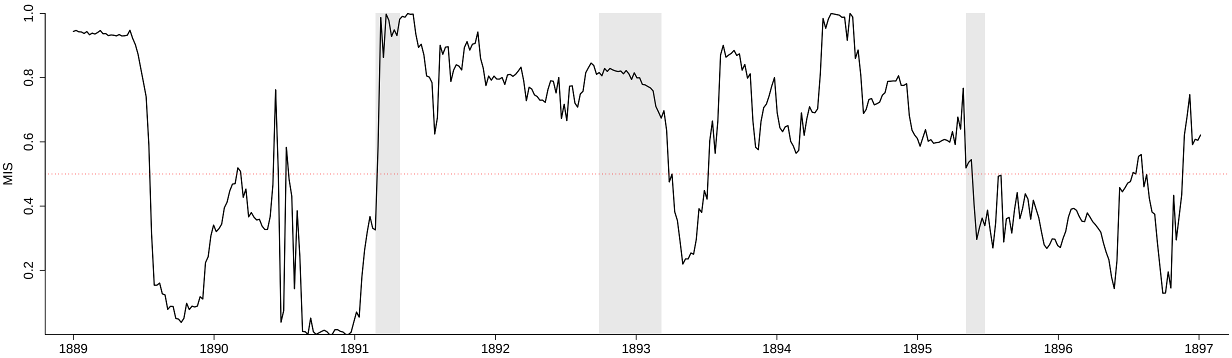
			CS			
Tests						
	$\text{SupF}_T(1)$	$\text{SupF}_T(2)$	$\text{SupF}_T(3)$	$\text{SupF}_T(4)$	$\text{SupF}_T(5)$	$\text{UD}max$
	95.950*	162.651*	138.559*	98.845*	68.310*	162.651*
	$\text{SupF}_T(2\|1)$	$\text{SupF}_T(3\|2)$	$\text{SupF}_T(4\|3)$			
	186.638*	51.155* .	0.000			
Break dates						
	Dates		95% lower bound		95% upper bound	
	1891(10)		1891(9)		1891(16)	
	1893(11)		1893(01)		1893(13)	
	1895(18)		1895(15)		1895(22)	
			IS			
Tests						
	$\text{SupF}_T(1)$	$\text{SupF}_T(2)$	$\text{SupF}_T(3)$	$\text{SupF}_T(4)$	$\text{SupF}_T(5)$	$\text{UD}max$
	80.819*	116.919*	92.846*	72.301*	48.700*	116.919*
	$\text{SupF}_T(2\|1)$	$\text{SupF}_T(3\|2)$	$\text{SupF}_T(4\|3)$			
	128.334*	28.964* .	6.219			
Break dates						
	Dates		95% lower bound		95% upper bound	
	1891(10)		1891(9)		1891(18)	
	1892(19)		1892(11)		1892(23)	
	1895(18)		1895(16)		1895(22)	
			MIS			
Tests						
	$\text{SupF}_T(1)$	$\text{SupF}_T(2)$	$\text{SupF}_T(3)$	$\text{SupF}_T(4)$	$\text{SupF}_T(5)$	$\text{UD}max$
	77.822*	143.764*	108.050*	84.422*	55.827*	143.764*
	$\text{SupF}_T(2\|1)$	$\text{SupF}_T(3\|2)$	$\text{SupF}_T(4\|3)$			
	176.883*	21.593* .	0.000			
Break dates						
	Dates		95% lower bound		95% upper bound	
	1891(10)		1891(10)		1891(18)	
	1893(7)		1892(39)		1893(10)	
	1895(21)		1895(19)		1895(26)	

Notes: Table 5 reports the results of conducting the Bai and Perron (1998, 2003) test on the estimated rolling-window price discovery measures CS, IS and MIS. Furthermore Table 5 shows the identified break dates with the corresponding 95% confidence interval boundaries. The estimated break date ares reported as year(week). * denotes statistical significance at the 5%-level. The trimming parameter is set to 15%.

Figure 2: Time-Varying Price Discovery Measures & Break Tests







Notes: Figure 2 depicts the time series of the three price discovery measures CS, IS and MIS. The price discovery measure time series are estimated by the rolling window VECM. The grey area indicates the 95% confidence interval of the corresponding structural breaks. The break dates are identified by the Bai and Perron (1998, 2003) test procedure with 15% trimming. The sample period is January 1889 to December 1896. The data frequency is weekly.