DISCUSSION PAPER SERIES

No. 5827

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FINANCIAL ECONOMICS

Centre for Economic Policy Research

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Available online at: **www.cepr.org/pubs/dps/DP5827.asp**

ISSN 0265-8003

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Discussion Paper No. 5827
September 2006

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CEPR Discussion Paper No. 5827

September 2006

ABSTRACT

Trading Costs in Early Securities Markets: The Case of the Berlin Stock Exchange, 1880-1910*

Based on daily prices (*amtliche Kurse*) we estimate effective spreads of securities traded at the Berlin Stock Exchange in 1880, 1890, 1900 and 1910. Several extensions of the Roll measure are applied. We find surprisingly tight effective spreads for the historical data, comparable with similar measures of the MDAX and DAX at the end of the 20th century.

JEL Classification: D23, G14 and N23
Keywords: effective spreads, market microstructure and price discovery

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* Without implicating them we thank Will Goetzmann, Cyril Monet, Albrecht Ritschl, Dick Sylla and especially Jan Annaert for very helpful and constructive comments. Tobias Brünner, Almira Buzaushina, Seth Freedman, Henry Gerbrandt and Gwendolin Gürtler provided excellent research assistance. We are also grateful for the support of Sevtap Kestel and the diligent work of the data collection team Nikolay Filipov, Mariya Onyshchenko, Patrick Rutkowski, David Speck and Lei Song – Without their careful efforts this paper would not exist. Financial support of the Alexander-von-Humboldt Foundation through its TransCoop Programme as well as the U.S. National Science Foundation is gratefully acknowledged.

Submitted 03 August 2006

1. Introduction

Price discovery is rather well understood in modern securities markets, yet relatively little is known about price determination and information aggregation in securities markets of the past. Securities markets began to emerge by the sixteenth century. These early markets—such as the stock exchanges in Holland (the Netherlands), England, France, Germany, and the US—are characterized by the spontaneous emergence of trading institutions in an otherwise essentially unregulated environment. With the liberalization of incorporation laws throughout most of the industrializing world in the mid-19th century, and as new technologies and industries sprang up, a range of equity shares took first place among the securities available in the marketplaces. These developments naturally attracted increasing attention to the exchanges, from investors and governments alike. Regulation appeared and developed apace, as markets grew more formalized, involved more participants, and traded larger volumes of more securities. Thus, studying early securities markets not only allows us to trace back the varying trajectories of modern trading institutions; it provides unique real world experiments as well.

The Berlin Exchange between 1870 and 1910 is of particular interest for a number of reasons. First, the last quarter of the nineteenth century marks the period when active trading in stocks emerged at the Berlin Exchange—Germany's dominant securities market of the pre-World War II era. Not coincidentally, this period also spans the later stages of German industrialization, the major industries and corporations of which attracted and circulated significant capital via the securities markets. In this respect, stock markets contributed to the rapid economic growth in that period. At the same time, the German states unified under a national system, and that new government promulgated a string of regulations on incorporation, corporate governance, stock market listing, transaction taxes, and trading. To some, the most critical of these laws was the comprehensive code of regulation for securities

trading set into force in 1896 (*Börsengesetz*), which would remain mostly intact until the Second Financial Markets Directive of the EU in 1994. The 1896 law marked the first instance of direct government restriction on the operations of the German markets, exemplified by the prohibition on futures trading in all but a few securities. Debates continue over the importance of the 1896 law, and tracking changes in effective spreads can provide critical insights into its net costs on efficiency.

One of the stipulations of the 1896 law separated banking functions from market making functions, and this point raises a second set of reasons for studying the Berlin market of the pre-WWI era. In particular, the period in question covers the ascent of the joint-stock universal banks to a position of national prominence and heavy involvement with certain sectors of the economy. Already by the first years of the twentieth century, and made famous by Alexander Gerschenkron in the 1960's, the universal banks' role in fueling industrial growth grew to mythic proportions. The banks' dominance in post-World War II Germany solidified their reputation as the key component in German corporate finance. With this institutional design and historical backdrop in mind, the recent finance literature considers Germany, and other countries with universal banks, as bank-based financial systems and draws a stark dichotomy between these and market-oriented (specialized banking) systems. Moreover, due to Germany's civil-law tradition, the so-called 'law and finance' literature views the country's financial-regulatory system as relatively unfriendly to markets; assuming that the legal system suppresses securities markets, making them small, thin, and informationally inefficient.[1] Thus, the common view over the past few decades displaces securities markets to the margins of Germany's corporate finance system.[2]

[1] See, for example, LaPorta et al (1998) on the apparent relationship between legal protections for investors and the type of legal system in place—common-law versus various types of ‚civil' law tradition—in a cross-section of countries. For a compact summary of the debates over 'bank-based' versus 'market-based' financial systems, see Levine (2002). For a more complex picture of comparative financial systems, see Allen and Gale (2000).
[2] See the recent volume surveying the German financial system, edited by Krahnen and Schmidt (2004).

Ongoing debates over financial system design still tend to view banks and markets as competitors or substitutes, leading to arguments about whether one or the other is consistently dominant in certain systems and to the current notion that these positions may have changed over time.[3] To address these debates at the most basic level, we need to assess the functioning of early markets relative to other markets during the same time and compared with their own performance over time. This study focuses specifically on the cost efficiency of Germany's main corporate securities market during its formative period of development. To be sure, the topic is narrow; but since we are examining the performance of a market operating within a system of universal and relationship banking, our results relate to the broader issue of the relationship between banks and markets: Can securities markets function efficiently in the presence of universal banks? Is there anything inherent in a civil-law tradition or in universal banking systems that hampers markets?

Thus, the current paper relates to the law and finance literature, and to the larger questions of complementarity between banks and markets. Given what we know about the German financial system of this period, we start out with the view that banks and markets can work as complements, and that some level of systemic complexity may well improve efficiency in the mobilization of financial capital.[4] While the analysis here cannot be construed as a direct test of a particular position in these debates, a finding of well-functioning markets would run counter to the notion that strong, universal-relationship banks supplant or inhibit securities markets.

The recent finance literature has developed a range of methods to test for the costs—implicitly the efficiency—of securities markets. We focus here on measuring effective

[3] See, most notably, Rajan and Zingales (2003), who coined the term 'great reversals,' to capture the idea that in many continental (civil law) European countries, financial development—including that of securities markets—superceded that in the U.S. and other common-law countries prior to World War I and that those positions reversed during the depression and World War II. Of course, such a characterization is necessarily broad-brush and not focused on institutional detail.

[4] See Fohlin (2006) for an in-depth discussion of the evolution of the German corporate finance system prior to World War I, in particular emphasizing complexity as well as balance and even symbiosis among segments of the system—especially universal banks and securities markets.

trading costs, or spreads, in the Berlin market, using the Roll (1984) measure and refinements thereof. Once we understand market functioning on average, we can determine how regulation affected price discovery later on, analyze the determinants of spreads at the firm level, and draw comparisons with other markets in other countries or later periods. If the "bank-domination" line of reasoning proves correct, then securities markets in universal bank-based systems may well produce higher trading costs. In particular, if dominant banks suppress market functioning and make for less efficient trading, then Germany should have higher estimated bid-ask spreads than the US, regardless of time period.[5]

On the contrary, our results indicate that trading costs were low in the Berlin market in the decades before World War I, even by modern US standards and certainly by recent German standards. These findings suggest two conclusions: First, universal banking in itself does not suppress market functioning or make them inefficient; using only recent data creates a skewed impression of the connection between universal banking and poor market performance. Second, securities markets functioned very well even 100 or more years ago. Indeed, given our modern comparison, German markets may have functioned more efficiently then than now. Modern-day economists often assume that national and international markets operated less efficiently in the distant past. The findings in this paper should help to change that view; demonstrating that market efficiency is not a recent phenomenon, and that market evolution has been highly uneven across countries and over time.

The results here underscore the usefulness of historical data for providing a much longer horizon over which to study the performance of markets and the role of institutions. While high-frequency data now available ostensibly provide statistical significance, economic phenomena evolve over much longer time-spans. In some respects—particularly international market integration, rapid technological change, and government regulatory stance—the pre-

[5] Of course, prior to the passage of the Glass-Steagall Act in 1933, the United States permitted financial institutions to combine investment and commercial banking services. Nonetheless, few would categorize the U.S. financial system as bank-dominated at any point over the past 100 to 125 years—especially not in comparison to Germany.

World War I economy and financial markets are more similar to their modern counterparts than were those of the inter-war and early post-World War II eras. Thus, a very long-run perspective offers modern finance the opportunity to make far more robust claims about the performance of securities markets and how efficiency might be promoted in the future.

2. The Berlin Stock Exchange and German Corporate Finance before WWI

Despite Germany's reputation as a bank-dominated corporate financial system, the German stock exchanges played an important role in the financial system during industrialization and long after. Indeed, the German stock exchanges trace their history back far earlier than the universal banks; the Cologne exchange having been founded in 1553.[6] Most governments heavily restricted charters for new share companies until the second half of the nineteenth century, meaning that few shares existed for trading on exchanges. The same was true in Germany, and the exchanges therefore listed primarily debt securities—heavily municipal and national, but also corporate—during this time. Banks, insurance companies, and railroads comprised the principle sources of equities on the exchanges until the 1860's and early 1870's, when, like many other countries in that era, the government liberalized incorporation laws. Even by 1870, a cumulative total of approximately 200 share corporations (*Aktiengesellschaften*) had formed in Prussia.[7] But after the 1870 company law standardized incorporation procedures and made the right nearly universal, hundreds of companies incorporated: over 900 between 1871 and 1873, more than half of which formed in 1872

[6] See Chapter 8 in Fohlin (2006, forthcoming) and the shorter historical review in Fohlin (2002). The primary American market, the New York Stock Exchange, began around the same time (1792). See the historical review by the New York Stock Exchange, www.nyse.com.
[7] See Horn (1979), p. 136.

alone. The population of AGs exceeded 3,000 by 1890 and surpassed 5,000 later that decade.[8]

Securities exchanges appeared in most areas of the German empire by the late nineteenth century, though many traded primarily in local issues. With the unification of the German empire in 1871 and the recognition of Berlin as the capital city, Berlin's exchange became the dominant German market—a position it retained until its demise in World War II.[9] Trading volume on the Berlin exchange averaged an estimated nine and twelve times that of Frankfurt and Hamburg, respectively, in the three decades before World War I.[10] Tax receipts (for both new issues and turnover) and numbers of shares listed reinforce the clear impression that the provincial exchanges lagged behind Berlin.[11] In the early years, even before its emergence as the primary German market, virtually all of the registered *Aktiengesellschaften* listed their shares in Berlin. Listings grew rapidly over the century, though less quickly than the overall boom in company flotations: the Berlin exchange listed approximately half of all joint-stock firms by the early 1870's, and still almost a third for most of the 1890's and early 1900's.

Underwriting new issues and admission of shares to official trading

While new issues of equity shares could be floated by direct subscription of shares, it was far more common by the late 19th century to use underwriting by a universal bank, in which case the bank purchased the full block of new shares and then sold them off to investors (*Übernahmegründung*).[12] This practice stemmed at least in part from the incorporation law of 1870 that stipulated full subscription of shares and minimum levels of payments for those

[8] Fohlin (2005) chronicles the post-World War I development of the German stock exchanges. Listings continued to increase rapidly during and shortly after the war. For an overview of several areas of recent German financial history, see the edited volume by Krahnen and Schmidt (2004).
[9] See Marx (1913), and Gömmel (1992).
[10] Wetzel (1996), p. 431 (Appendix VI).
[11] Note that Frankfurt listed nearly as many foreign securities as did Berlin. See also Wormser (1919), p. 229, for tax receipts in Berlin, Frankfurt, and Hamburg between 1900 and 1913.
[12] Interestingly, the railroad boom in Germany (1840's to 1860's) was largely financed by the subscription method, that is, "successive issue."

stakes. Firms also needed to insure subscription of shares within a specified timeframe and a minimum level of attendance at the initial meeting of shareholders. Failure to meet the regulations meant large losses to the company founders and justified the expense of floating shares through an informed underwriter—often a Berlin-centered universal bank—who would hold the shares on its own account, if necessary.

Government regulation of corporate finance typically followed on the heels of crises. The boom of the early 1870's ended as abruptly as it started; the massive losses starting in the mid-1870's provoked a popular outcry and demands for greater protections for shareholders via regulations on incorporation, corporate governance, and securities market activities. The 1884 company law, along with exchange regulations of 1881 and 1884, increased the responsibilities of firms and their governing bodies to perform well, to oversee operations responsibly, and to reveal more and better information to potential shareholders. To the extent that these stipulations improved both the quality of listed shares and the information available on them, the laws may well have enhanced investors' trust of the securities markets, lowered trading costs, and encouraged more active trading.

The economy emerged from stagnation in the late 1880's, prices rose again, and, in 1890 and especially 1891, they fell again. This time, price declines hit agriculture especially hard, and the large agrarian sector blamed their losses on futures trading in commodity markets. In 1892, the national government formed a commission to investigate the operation of the exchanges and recommend remedies. The new stock exchange law that resulted in 1896 imposed a number of new restrictions—fully paid-in equity shares, waiting periods, and published financial statements, for example–on companies wishing to officially list shares on the exchange. The 1896 law also created new governing institutions for the stock exchanges—a commissioner (*Staatskommissar*), the *Ehrengericht* (a judiciary body), and the *Börsenausschuss* (a committee of experts)—in order to insure closer scrutiny of new issues. The law also dictated greater independence of the committee tasked with admitting securities

to the exchanges (the *Zulassungstelle*); stipulating, for example, that half the members must not be listed in the stock exchange register, a third must not be involved in securities trading, and nobody involved in a new issue would be permitted any say in the acceptance of that issue to trading.[13] The legislation reinforced the liability clauses of the 1884 law, holding underwriters accountable for the accuracy of information they provided to investors.

The most notorious provision of the 1896, by far, was the prohibition on futures trading in the securities of most non-financial corporations as well as in a wide range of agricultural commodities (grain and mill products). Popular opinion had connected price volatility to futures trading, but many argued that speculation in futures actually stabilized prices.[14] Debate over the proposed ban raged, but the agrarians and other proponents ultimately prevailed over industrialists and financiers. The futures ban essentially shut down the Berlin commodities exchange; it may also have hindered the operation of the spot securities market.[15] By some accounts, however, the courts enforced the provision unevenly, and, even for restricted securities, some futures trading persisted after 1896.[16] The 1908 *novelle* to the stock exchange law then rescinded the blanket prohibition of futures trading.

Price setting on the exchanges

The pricing process at the German securities exchanges changed little over the half century before World War I. Throughout the period, the exchanges operated as call auctions, and brokers set a final, binding price only once per day in order to maximize volume for each security. In the early years, it is thought that bankers played an active role in price discovery, even directly performing brokerage functions, particularly in thin markets.

[13] See Wiener (1905).
[14] Prion (1910, 1929) and Meier (1993).
[15] Fohlin (2002) finds little evidence that the new law reduced market activity, but some evidence that tax levies a few years earlier diminished turnover to some extent.
[16] Buss (1913), and Bund der Landwirte (1908).

Legal changes in 1884 and 1896 did tighten provisions regarding the exchange brokers and attempted to insure their independence. The first step, in 1884, formalized the appointment official brokers (*vereidigte Maklern*), stipulated life terms for them, and prohibited them from trading on their own accounts or with other brokers.[17] Despite these regulations, bankers or other interested parties could possibly influence price setting, if only through purchases and sales of securities themselves. Critics continued to call for further reform of the official broker system, and complaints grew particularly loud in the aftermath of the 1891 crisis.

As with other provisions in the 1896 stock exchange law, the government attempted to appease the investing public by formalizing the official brokers (called *Kursmaklern*) and attempting to further insulate the price discovery process from outside influences. According to the new law, exchange directors would set official prices solely in conjunction with the commissioner, secretary, brokers, directors, and representatives of other trades prescribed by exchange regulations. Long after the law went into effect, commentators still noted the involvement of banks—particularly the universal banks—in price setting on the exchanges.[18] Thus, banks may well have taken part in price discovery in the Berlin market and may have substantially affected the levels or volatility of prices there. At the same time, their involvement in price setting would have simultaneously limited the banks' ability to exploit their privileged access to information.

3. Methodology: Measuring Effective Spreads

The empirical analysis is based on variants of the Roll measure for effective bid-ask spreads (Roll, 1984), and a measure of total transactions costs developed by Lesmond, Ogden, and Trzcinka (1999).

[17] Some brokers apparently often did trade on their own accounts nonetheless.
[18] See especially Passow (1920), who described bankers (underwriters) as *Schutzpatronen* (literally, patron saints) of their client firms' shares. It may be inaccurate to assume his commentary applies to the pre-war era.

Let $r_{it} = \frac{p_{it} - p_{it-1}}{p_{it-1}}$ denote the transactions return on a security *i* in period *t*, where p_t is the stock price.[19] Then the Roll measure $s_i^R = 2\sqrt{-\operatorname{cov}(r_{it}, r_{it-1})}$ is an estimate of security *i*'s effective spread. Note that the effective spread is smaller than a quoted spread, since transactions regularly occur at prices between the quoted bid and the ask prices.

The basic idea of Roll's spread estimator is that in informationally efficient and stationary markets all variation in transactions prices is caused by the randomness of buy and sell orders given and the existence of positive transaction costs. In liquid markets with low transaction costs, successive individual orders will have little impact on observed transaction prices. In thin markets, price effects of individual trades may be more pronounced. If transaction costs are higher, the deviation of transaction prices from true fundamentals will not be immediately arbitraged, even in efficient markets. Therefore, the covariance of successive price changes is informative about effective transaction costs.[20]

Roll argues that the effective spread provides a better estimate of the effective transaction costs actually incurred by market participants compared to the quoted spread—a piece of information that may be unavailable in many cases. Indeed, since the Berlin Exchange operated as an auction market in the period in question, bid-ask spreads would not have been produced.

To be sure, the Roll measure has well known deficiencies; for example, the requirement of negative returns covariance. Especially, when (unobserved) securities returns are positively auto-correlated, transactions returns may also be positively correlated. But even in the case in which the Roll measure exists, it is downward biased whenever (unobserved)

[19] The transactions return is based on observed transactions prices. It should be differentiated from the unobserved true return of a security, which is based on its hypothetical true value. Transactions returns will typically differ from true returns, because even in efficient markets transactions costs prevent arbitrage, when true returns and transactions returns are close enough. In the sequel we will reserve the term "returns" exclusively for transactions returns.

[20] See Madhavan (2000) for a more technical survey on the empirical estimation of transaction costs.

securities returns are positively auto-correlated (George, Kaul, and Nimalendran, 1991).[21] While we can assess the likely size of the bias based on Harris (1990), we employ a refinement of the spread estimates based on George, Kaul, and Nimalendran (1991) to correct for positively auto-correlated securities returns. The GKN approach runs as follows: let $r_t^m = \frac{1}{N}\sum_i r_{it}$ denote the return of the equal-weighted market portfolio and $r_{t,t-1}^m$ denote the one-period-ahead forecast thereof. Then the projection of r_{it} on $r_{t,t-1}^m$ (r^m) yields the residuals $\varepsilon_{it} = r_{it} - \hat{\alpha}_i - \hat{\beta}_i r_{t,t-1}^m$, which are not explained by fundamental valuations. The covariance measure of these residuals should therefore provide a better spread estimate. The GKN estimator coincides with the Roll measure when the estimated regression parameters $\hat{\beta}_i = 0$. In many applications, including our own, typically $\hat{\beta}_i > 0$, in which case both effective spread estimators are downward biased. The GKN-estimator, however, is less biased than the Roll estimator. If the expected return of the equal-weighted portfolio, $r_{t,t-1}^m$, is a perfect proxy for the expected (unobservable) securities return, the GKN measure is unbiased.

Since we will see that both measures are not fully satisfactory for our analysis, we also implement the estimator suggested by Lesmond, Ogden, and Trzcinka (1999). In contrast to the earlier measures, the LOT estimator measures the complete cost of a roundtrip transaction, effective bid-ask spreads plus transaction taxes and commissions. It is based on the idea that arbitrage will take place only outside the band of effective transaction costs around the security's true value. So there are thresholds $\underline{\alpha}_i$ and $\overline{\alpha}_i$ such that the measured return r_{it} depends on the true return r_{it}^* in a linear way $r_{it}^* = \beta_i r_{it} + \varepsilon_{it}$, where

[21] See Harris (1990) for an in-depth analysis of the statistical properties of the Roll estimator. Also, note that in Roll's own study, only a portion of his sample satisfied this negative covariance criterion.

$$r_{it} = \begin{cases} r_{it}^{*} - \underline{\alpha}_i & \text{if} \quad r_{it}^{*} < \underline{\alpha}_i \\ 0 & \quad \underline{\alpha}_i < r_{it}^{*} < \overline{a}_i \\ r_{it}^{*} - \overline{\alpha}_i & \quad \overline{\alpha}_i < r_{it}^{*} \end{cases}$$

This is the so-called limited dependent variable model, originally proposed by Tobin (1958) and Rosett (1959).

The estimated difference $\overline{\alpha}_i - \underline{\alpha}_i$ is a measure of the true roundtrip transaction costs.[22] Accordingly, this estimator encompasses not only the bid-ask spread but also commissions and transaction taxes. Therefore, the LOT estimator overestimates the effective bid ask spread. It provides, however, an unbiased estimator of the roundtrip transaction costs. Naturally, due to the structure of trading in the pre-WWI Berlin market, we cannot use other Roll-measure refinements that require information on bid and ask prices or on the nature of transactions (buy versus sell).

4. Data

In order to estimate effective spreads, we need daily closing prices for a range of securities traded at the Berlin Stock Exchange.[23] The data for this exercise comes from the *Norddeutsche Allgemeine Zeitung*, which published a daily record of the Berlin market. As a starting point, we chose four years (1880, 1890, 1900 and 1910), and we continue to gather

[22] Note that this model can also be generalized readily to the case of non-zero returns of the underlying market model. In our framework the zero-return assumption cannot be statistically discarded (see Table 0).

[23] As a referee points out it might be preferable to use continuous data. While this desideratum is not questioned the only data available are the call auction data. Moreover, the method we employ was developed and applied to daily data as well by Roll (1984). Thus, at least, the results are comparable to some extent across time and region.

data for additional years.[24] Since trading took place six days per week—every day, except Sundays and holidays—each security has about 300 to 306 observations per year.[25]

We included all recorded stocks for the following sectors: banking, transportation, metal, mining, construction, chemicals, paper and glass, textiles, breweries, and electrical (as of 1900). This comprehensive approach helps minimize the possibility of selection bias. Given the rapid increase in stock market listings over the period, the sample grows over time and its sectoral composition changes to some extent as well (see Table 1).

Overall our dataset includes 43 stocks for 1880, 94 in 1890, 114 in 1900, and 165 in 1910. All told, the sample includes roughly 154,000 daily price observations.[26] Table 1 describes the statistical properties of the full sample. Moreover, we have collected historical size data (paid in share capital – AK: *Aktienkapital*) and debt equity ratios (DER) for the years 1890, 1900 and 1910. This information is not available for 1880.

While the four sample points extend over several decades, we refrain from drawing strong conclusions about trends over the period. We note, however, that the financial turmoil of the early 1890's and resulting regulatory changes of 1896, coupled with the rapid expansion of stock market listings starting in the second half of the 1890s, suggests a potential structural break between our first two and second two years. In addition, if the 1884 company law succeeded in improving corporate governance and information quality for outside shareholders, its effect may appear in our results in the form of a reduction in trading costs between 1880 and 1890. As the data gathering process continues, we will ultimately have data sufficient to test for more continuous-time phenomena, such as a significant change in

[24] The newspapers are in microfiche form, and it remains technically impossible to machine read these microfiches (as of 2006). Since the data must therefore be coded manually, the process is lengthy and costly; imposing obvious limits on the number of years that can be covered for now.

[25] We know of no other daily stock price databases for Germany, and there are only a few collections of monthly historical stock prices. See Eube (1998), for example, who has used the data for index analysis. However, these data are too coarse for event or market microstructure analysis.

[26] This work was performed by 8 research assistants over the period of several months at the University of Freiburg with considerate support of the University Library.

transactions costs following the 1896 law or other political-economic-legal events of the time.[27]

We compare these data with modern evidence from the German markets. The lower panel of Table 2 presents the statistical properties of the modern time series, in particular DAX- and MDAX-returns for 1990-91, 1995-96 and 2000-01.

5. Empirical Results

The empirical analysis consists of four parts: i) First we provide estimates of the effective historical spreads and ii) total transaction costs at the Berlin Exchange based on daily return series, then iii) we compare the performance of the early Berlin exchange with performance measures of the modern markets in Germany in 1990 and 2000, and finally iii) we relate our historical measure of trading costs to observable characteristics of the underlying firms, and particularly firm size.

Before we compute spread measures we eliminate time series with too little return variation. We exclude from the sample all return series with more than 100 entries equal to zero or less than 60 observations in a given year. This elimination procedure leaves 43 securities in 1880, 90 in 1890, 113 in 1900 and 162 in 1910. The statistical properties of the remaining securities are reported in Table 2. For the interpretation of the statistical analysis the number of zero-ticks is of particular importance. It turns out that the number of zero returns in the historical data is roughly comparable to the corresponding number in MDAX. There are fewer zero ticks in modern DAX time series. Table 3 reports the incidence of zero ticks across size classes in those years where size information was available, i.e. in 1890, 1900 and 1910. Interestingly, the number of zero ticks increased over time. With the exception of the year 1910 the relation between firm size and number of zero ticks tends to be

[27] In the meantime, we look to studies such as Fohlin (2002), who pulls together a variety of evidence against a dramatic structural shift surrounding the 1896 law (and indicating, instead, that increasing taxation on stock market transactions may have depressed trading somewhat).

negative: the larger the firm, the more likely the stock changed price from one day to the next. Outliers in the continuously compounded return series are removed using the procedure proposed by Tsay (1986) and assuming that the returns follow an AR(1) model.

i) Estimates of the effective spread

As a benchmark, Table 4 presents the Roll estimates in the first column for each year. Like Roll, we find a large number of negative spread estimates (see Figure 1); a problem that appears whenever a time series of daily returns is positively auto-correlated.[28] Since effective spreads are non-negative, clearly, the average Roll measure (according to Roll's own convention) provides a downward biased measure of the (hypothetical) true value of the underlying average Roll measure. Harris (1990) provides a rigorous statistical analysis of the Roll estimator and shows that noise in the serial covariance estimator and Jensen's inequality help to explain why the Roll measure often results in negative effective spreads. George, Kaul, and Nimalendran (1991) show that positively auto-correlated unobservable expected returns lead to severely downward biased and even negative spread estimates. Indeed we find positive autocorrelation for many return series. So the corresponding GKN estimates—based on method I of George, Kaul, and Nimalendran (1991)—generally exceed the Roll estimates. They also appear more consistent with the assumptions (fewer negative spreads).

Table 4 presents the (equal-weighted) average spreads for the full sample in each year also for the remaining two procedures. Since the equal-weighted index is positively auto-correlated the Roll measure is more strongly downward biased than the measure by George, Kaul, and Nimalendran. However, ranging from 0.25-0.4, the autocorrelation coefficients are relatively low and according to George, Kaul, and Nimalendran (1991) the downward bias of both measures should be moderate.

[28] The appended descriptive statistics show that there is considerable momentum in various return series.

For 1880 and 1900, even the average of the estimated Roll measures turns out negative. Given that the true underlying average trading cost must be bounded below by zero, that measure is completely uninformative. At the same time, the GKN measure is consistently positive. Moreover, the GKN-measure suggests a slight decline in effective trading costs over the decades, and that finding adds to the measure's plausibility. The Roll measures suggest either a highly efficient market or a considerable understatement of the real trading costs. Also of note, the GKN-measure seems to pick up the crises year 1900, while the Roll measure does not.

Remarkably, these results are slightly lower than Roll's own (daily) estimates and significantly lower than Roll's weekly estimates for the New York and American Stock Exchange from 1963 to 1982. He finds an average effective percentage spread of 0.298 for daily observations and 1.74 for weekly observations. Given the high degree of efficiency typically attributed to the NYSE, especially in the post-war period, the low estimates for pre-WWI Berlin might come as a surprise.

ii) Estimates of total trading costs

Lesmond et al. (1999) provide an alternative measure of trading costs. They argue that arbitrage is only profitable if gross proceeds exceed total transaction costs, i.e. bid-ask spread plus commissions and taxes. Hence small deviations from the true underlying price within the band of transaction costs will not trigger arbitrage activity. Only when prices leave this band will profitable arbitrage emerge. The authors develop an straightforward maximum likelihood estimator, which is easy to handle and, unlike the Roll measure, possesses desirable statistical properties. Moreover, unlike the earlier estimators of transaction costs, the Lesmond et al. (1999) procedure also applies under conditions of asymmetric information or adverse selection. For such situations Glosten (1987) establishes that the Roll measure may seriously

under-estimate true transaction costs. Therefore, the LOT-measure also provides a welcome benchmark test.

Average overall trading costs fall monotonically from about 1.16 percent in 1880 to 0.45 % in 1910 (Table 4). Note that this trading cost constitutes an upper bound on the bid-ask spread, confirming that the LOT measures consistently exceed the Roll- and the GKN-measures. Overall transactions costs declined most dramatically between 1880 and 1890, falling from 1.16 percent to 0.69 percent on average. Interestingly, average trading costs only decreased from 0.69 percent in 1890 to 0.53 percent ten years later. So, in net the Börsengesetz of 1896 seems to have had little impact on spreads.[29]

iii) Performance comparison with modern exchanges

Bid-ask spreads and overall trading costs seem to have been rather low at the Berlin Stock Exchange. To back up this impression, it is illuminating to compare those trading costs with markets characterised by a different organisation of trading. In principle such comparisons can most easily be made across contemporaneous exchanges, such as London and New York in the same period, or in the same country across time. Both types of comparisons have their own merits and weaknesses. Comparing contemporaneous exchanges helps control for the global environment.[30] At the same time, comparing one country's exchanges over time permits the examination of long-run patterns, as well as assessment of the impact of regulatory and technological change.[31]

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[29] The specific consequences of the 1896-law remains an open issue that we cannot resolve with our present data set. Increases in transactions taxes clearly have affected trading costs and counteracted potential gains in liquidity. However, it remains to be analyzed whether liquidity gains were uniform across size classes and industries, if they existed at all.

[30] The historical approach, unfortunately, suffers from data limitations. Historically, comparatively little information has been recorded, and moreover, some of this information has been destroyed meanwhile, such as the archive of the Berliner Börse.

[31] Of course, in increasingly integrated markets the evolution over time will also increasingly be affected by the development in those other markets, and the microstructure of competing markets. However, one might still feel tempted to view domestic factors as the dominant ones.

Comparing performance measures of the early Berlin Stock Exchange with performance statistics of the DAX-30 securities in 1990 and in 2000 yields interesting results. Two years are particularly important: 1990, because it predates the significant regulatory changes of 1994; and 2000, because the longer-run effects of the new laws would have largely emerged. Tables 5 and 6 give the corresponding results for the German DAX-30 and MDAX in the years 1990/1, 1995/6 and 2000/1.[32] Since the data are more readily available, these contemporary estimates of the Roll measure use 2 continuous years of data in order to increase precision.

These new estimates indicate that both the Roll measure and the GKN-measure are uninformative for the modern German markets: average estimated trading costs are negative, which obviously cannot be. However, the LOT measures are quite informative. With the exception of estimates for 1880, the historical transactions cost measures lie between the contemporaneous DAX and MDAX measures. This result suggests a surprisingly high degree of efficiency in historical price determination. The advances of the technological revolution seem to have done little to reduce the transaction costs of securities trading on net relative to the historical measures. While it is hard to imagine that technology has not facilitated more trading, and we cannot determine whether new trading systems would have lowered costs ceteris paribus, we can say that on net such hypothetical savings must have been offset by increases in trading costs stemming from other sources.

Overall, these various measures indicate that effective trading costs of the early Berlin Stock Exchange compare quite closely to those in the modern German stock exchanges after the extensive liberalizations of the 1980's and 1990's. Since effective trading costs declined significantly in the post-war period, our findings for the pre-World War I era imply that effective trading costs at the German stock exchanges must have risen substantially between the two world wars.

[32] We used daily prices of the closing call auction.

iv) Determinants of effective spreads and transaction costs

The findings thus naturally lead us to ask why? In particular, one would like to understand the relationship between trading costs and the financial structure of the firms in question. For example, thinly traded stocks may be more prone to insider trading and therefore command higher effective spreads in order to protect less informed market makers. In order to offer some insight on these questions, we use the book value of equity shares (AK – *Aktienkapital*) and the debt equity ratio (DER) for each company in our sample. Unfortunately, ownership information is generally unavailable, and even when present, the data are too rough for empirical implementation.[33]

Surprisingly, the original Roll and GKN-measures correlate very weakly with these financial structure variables (Tables *8* and *9*). Arguably, we miss some relevant information about the relative share of stocks in circulation or about ownership structure. Additionally, one might argue that both of our spread estimates are too noisy to generate statistical significance.

In contrast, however, overall transaction costs as measured by the LOT measure are predictable in the early years on the basis of company size. Table 9 suggests that the degree of predictability may have diminished from 1890 to 1910, but it remains significant. There is a clear size effect in overall trading costs that cannot be detected in our bid-ask spread measures. This size effect is not related to transaction taxes either. So the result could stem from the structure of commissions or, alternatively, from a size effect in the underlying market model.

In order to explore this size effect we estimated the various spread measures separately for the four quartiles (Table 7). While neither the Roll nor the GKN measure suggests a strong relationship between trading costs and size class, the LOT measure indicates a clear

[33] Data come from Saling's Börsen-Jahrbuch.

negative relation between size and overall trading costs.[34] This measure suggests that larger stocks tend to attract more liquidity and hence command lower spreads. The effective roundtrip costs measure 63-101 basis points for the smallest size quartiles but only 18-29 basis points for the largest firms. These numbers are surprisingly small. For example, they are much smaller than the number reported by Lesmond et al. (1999) for an NYSE/AMEX data set from 1963-1990, who find 123 basis points for large companies and 1045 for small ones.

Our estimates for the largest companies are broadly in line with the ranges of (effective) transactions costs reported by Weigt (2005, table IV.18): in the range of 15-38 basis points for brokerage fees plus commissions. While this range roughly corresponds with the estimates for the largest firms in our sample, it significantly understates estimated trading costs for smaller firms (second quartile and below). Her underlying data are less informative than ours, however, in that she derives her estimates from monthly data, while we have collected daily returns.

6. Relation to Earlier Work on Historical Securities Markets

Until very recently, few scholars have looked back to the securities markets of pre-WWI Germany; almost no work has been done on the performance of these early secondary markets. Fohlin (2002, 2006) hypothesizes that this scholarly neglect may reflect the general (modern) view that these early markets must have been highly inefficient and relatively unimportant within the universal banking system that dominated both academic and public discourse in the post-WWII era.

The lack of attention is currently being addressed in a number of detailed studies, yet the focus often remains on the prevalence of the universal banks. Indeed, in one relatively early contribution to this new line of work, DeLong and Becht (1992) interpret the low degree

[34] It should be noted that "Aktienkapital" may not be the best proxy of size. It's the only available proxy though.

of volatility in the period 1876-1913 as evidence for the dominant role of banks as financial intermediaries. Thus, according to this view, and consistent with Allen and Gale's (2000) perspective on insider-dominated financial systems, the predominant activities of intertemporal transfers and risk sharing are attributed to the less transparent banking sector.

In contrast to DeLong and Becht, who consider monthly observations of an index, we compare individual securities and branches on a daily frequency. This technical difference yields quite different results. We find that return volatility in the Berlin Exchange is roughly comparable to return volatility in modern stock markets. To be sure, our finding still allows for significant in-house netting of trades by bankers, as well as of extra volatility due to fragmentation, since many securities were listed and traded in different regional exchanges at that time. So it is important to acknowledge that we may only observe a small segment of overall trading in individual securities. Nevertheless, it appears that the performance of the early Berlin Exchange—at least in terms of trading costs—differs little from that of modern exchanges.

7. Conclusions

Overall, a favorable picture emerges from the results here: in particular, that trading costs at the Berlin Stock Exchange were low throughout the later stages of industrialization (1880-1910), and furthermore, that informational efficiency, seems to have increased towards the end of that period. In other words, Germany's principle securities market of the pre-WWI era performed remarkably well, even by modern US standards and certainly by recent German standards. The findings support multiple interpretations. Quite plausibly, the Berlin banks may have intervened in price determination as informed market makers and thereby reduced adverse selection costs. On the other hand, the efficient use of information seems to have increased only gradually over time, even as bank-firm relationships were growing more

complex and indirect.[35] What we can say with some certainty is that the Berlin Stock Exchange thrived despite the emergence of powerful universal banks during that time.

The results here also allow a preliminary judgment on the widely-condemned stock market regulation of 1896: first, the *Börsengesetz* seems to have made an imperceptible impact on transaction costs, at least on net. While our results cannot reject the hypothesis that the new law prevented costs from falling even further, the findings do at least indicate that the law did not increase costs over their past values. Informational efficiency also increased after the imposition of the trading restrictions. Again, we cannot reject the notion that the law dampened what would have amounted to even more impressive gains. Only further data collection and analysis for Berlin and comparable cases will shed more definitive light on the impact of regulatory change. At least this provisional assessment suggests more mild effects on the market itself than those claimed in the past.

These findings also have broader implications about the effects of financial system design: First, the existence of universal banks, in and of itself, neither relegates markets to obscurity nor renders them inefficient. Indeed, we have provided one striking example in which strong banks and strong stock exchanges did co-exist. Second, some markets functioned very well even 100 or more years ago. Modern economists often assume that national and international economies operated less efficiently in the distant past. By applying modern methods and using large-scale historical data, the findings in this paper should help to change prevalent views on the functioning of financial markets and institutions. Clearly, market efficiency is not a recent phenomenon, and market evolution has proceeded in highly uneven fashion across countries and over time. In particular, more recent history often creates a false impression that universal banking induces or at least correlates to poor market performance.

[35] Fohlin (1999). See also Wellhöner (1989) for details on a few prominent cases.

As a final note, this study points to the need for much further research into historical financial markets. Establishing robustness is of primary importance and requires continued efforts in collecting daily data of the kind presented here. While such data gathering is admittedly extremely costly in time and funding, the results of this study suggests that such investments will bring rewards. The next step involves contemporaneous comparisons of price discovery across the Channel and across the Atlantic with the exchanges in London and New York. London was far more developed by the time and certainly served as the benchmark model when the German stock exchange law was drafted and debated between 1893 and 1896. New York, on the other hand, is interesting because the industrialization of the US more or less coincided with the German one, yet the US financial system developed along quite different lines. Only additional research will tell what role these institutional and regulatory differences have played in determining the relative efficiency of price discovery and the costs of transacting in securities markets. .

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Table 1: Descriptive Statistics (Full Historical Sample)

year	# of firms	avg. # of obs.	avg. # of zeros	avg. mean	avg. std.dev
1880	43	282	85	0.0015	0.0125
1890	94	268	68	-0.0004	0.0095
1900	114	290	64	-0.0004	0.0091
1910	165	294	69	0.0000	0.0110

Descriptive statistics of the full Berlin sample in the years, 1880, 1890, 1900 and 1910.

Table 2: Descriptive Statistics (Refined Sample)

Year	# of firms	avg. # of obs.	avg. # of zeros	avg. mean	avg. std.dev.
1880	43	283	83	0.0001	0.0089
1890	90	272	65	-0.0003	0.0081
1900	113	292	64	-0.0003	0.0077
1910	162	296	67	0.0001	0.0056

DAX:

Year	# of firms	avg. # of obs.	avg. # of zeros	avg. mean	avg. std.dev.
1990-91	20	522	27	-0.0003	0.0163
1995-96	23	466	17	0.0005	0.0117
2000-01	29	497	21	-0.0003	0.0239

MDAX:

Year	# of firms	avg. # of obs.	avg. # of zeros	avg. mean	avg. std.dev.
1990-91	29	502	45	0.0000	0.0173
1995-96	47	522	58	-0.0003	0.0164
2000-01	49	503	28	0.0000	0.0258

Descriptive statistics of the actual data used for the statistical analysis. The upper panel presents the Berlin data for 1880, 1890, 1900 and 1910. The middle panel present the DAX data and the lower panel the MDAX data.

Table 3:

Year	avg. obs.	avg. # of zeros	avg. miss.obs.	avg. mean	avg. std.dev.
1890					
1. quartile	296	43	3	-0.0003	0.0072
2. quartile	289	57	10	-0.0005	0.0087
3. quartile	285	71	14	-0.0003	0.0076
4. quartile	281	92	18	-0.0003	0.0083
1900					
1. quartile	296	52	7	-0.0003	0.0074
2. quartile	298	49	5	-0.0004	0.0079
3. quartile	294	70	9	-0.0004	0.0077
4. quartile	290	86	13	-0.0002	0.0079
1910					
1. quartile	299	72	2	0.0000	0.0037
2. quartile	299	53	2	0.0000	0.0055
3. quartile	299	79	2	0.0001	0.0063
4. quartile	297	67	4	0.0002	0.0071

Descriptive statistics of the Berlin sample broken down by firm size for the years 1890, 1900 and 1910.

Table 4: Average percentage spread according to Roll (1984), George, Kaul Nimalendran (1991) and roundtrip transaction costs according to Lesmond, Ogden, Trzcinka (1999)

			Average spread measures in %
Year	**Roll**	**GKN**	**LOT**
1880	**-0.04**	**0.28**	**1.16**
1890	**0.01**	**0.15**	**0.69**
1900	**-0.06**	**0.17**	**0.53**
1910	**0.10**	**0.11**	**0.45**

Roll: spread measure according to Roll, $s_i^R = 2\sqrt{-\operatorname{cov}(r_{it}, r_{it-1})}$

GKN: spread measure according to George,Kaul, Nimalendran

LOT measure of transaction costs according to Lesmond, Ogden, Trczinka, $\overline{\alpha}_i - \underline{\alpha}_i$.

Table 5: Measuring effective trading coss of the DAX-30 according to Roll (1984), George, Kaul Nimalendran (1991) and roundtrip transaction costs according to Lesmond, Ogden, Trzcinka (1999)

			Average spread measures in %
Year	**Roll**	**GKN**	**LOT**
1990/1	**-0.67**	**-0.67**	**0.31**
1995/6	**0.11**	**0.11**	**0.12**
2000/1	**-0.87**	**-0.34**	**0.27**

Roll: spread measure according to Roll, $s_i^R = 2\sqrt{-\mathrm{cov}(r_{it}, r_{it-1})}$

GKN: spread measure according to George,Kaul, Nimalendran

LOT measure of transaction costs according to Lesmond, Ogden, Trczinka, $\overline{\alpha}_i - \underline{\alpha}_i$.

Table 6: Measuring effective trading coss of the MDAX according to Roll (1984), George, Kaul Nimalendran (1991) and roundtrip transaction costs according to Lesmond, Ogden, Trzcinka (1999)

			Average spread measures in %
Year	**Roll**	**GKN**	**LOT**
1990/1	**-0.75**	**-0.11**	**0.88**
1995/6	**-0.49**	**-0.33**	**0.82**
2000/1	**-0.09**	**0.19**	**0.54**

Roll: spread measure according to Roll, $s_i^R = 2\sqrt{-\mathrm{cov}(r_{it}, r_{it-1})}$

GKN: spread measure according to George,Kaul, Nimalendran

LOT measure of transaction costs according to Lesmond, Ogden, Trczinka, $\overline{\alpha}_i - \underline{\alpha}_i$.

Table 7:

Year	Roll-spread	GKN-spread	LOT
1890			
1. quartile	0.2266	0.1315	0.1829
2. quartile	-0.1081	0.1306	0.5517
3. quartile	0.1162	0.3018	0.6178
4. quartile	-0.1459	0.0862	1.0119
1900			
1. quartile	-0.1342	0.1480	0.2914
2. quartile	-0.1180	0.1252	0.3835
3. quartile	0.0344	0.2383	0.6109
4. quartile	0.0051	0.1968	0.8255
1910			
1. quartile	0.0892	0.0907	0.2749
2. quartile	0.1935	0.2043	0.3323
3. quartile	0.0563	0.0703	0.5638
4. quartile	0.0499	0.0932	0.6291

Roll: spread measure according to Roll, $s_i^R = 2\sqrt{-\operatorname{cov}(r_{it}, r_{it-1})}$

GKN: spread measure according to George,Kaul, Nimalendran

LOT measure of transaction costs according to Lesmond, Ogden, Trczinka, $\overline{\alpha}_i - \underline{\alpha}_i$.

Table 8: Determinants of effective spreads/roundtrip transaction costs

$s = const + \beta_1 \ln(AK) + \beta_2 DER + \varepsilon$					
	Dependent variable	β_1	β_2	**Adj. R^2**	**#Obs**
	Spread (Roll)	0.06 (0.99)	0.002 (0.10)	-0.01	90
1890	**Spread (GKN)**	-0.04 (-0.72)	0.004 (0.21)	-0.02	90
	Spread (LOT)	**-0.27** **(-7.26)**	**0.03** **(1.78)**	**0.43**	**90**
	Spread (Roll)	-0.06 (1.36)	0.01 (0.65)	-0.001	113
1900	**Spread (GKN)**	-0.01 (-0.7)	-0.002 (0.10)	-0.02	113
	Spread (LOT)	**-0.19** **(-6.94)**	**0.01** **(1.09)**	**0.31**	**113**
	Spread (Roll)	0.02 (0.96)	-0.000 (-0.03)	-0.01	162
1910	**Spread (GKN)**	0.01 (0.58)	-0.001 (0.10)	-0.01	162
	Spread (LOT)	**-0.13** **(-5.63)**	**0.01** **(1.12)**	**0.17**	**162**

endogenous variables:

Roll: spread measure according to Roll, $s_i^R = 2\sqrt{-\mathrm{cov}(r_{it}, r_{it-1})}$

GKN: spread measure according to George,Kaul, Nimalendran

LOT measure of transaction costs according to Lesmond, Ogden, Trczinka, $\overline{\alpha}_i - \underline{\alpha}_i$.

explanatory variables:

AK: book value

DER: debt-equity ratio

Table 9: Correlations of spread estimators and financial structure variables.

1890	**AK1890**	**DER**	**GKN**	**LN(AK1890)**	**LOT**	**ROLL**
AK1890	1.00	0.66	-0.01	0.85	-0.46	0.20
DER	0.66	1.00	-0.01	0.46	-0.16	0.08
GKN	-0.01	-0.01	1.00	-0.04	0.06	0.78
LN(AK1890)	0.85	0.46	-0.04	1.00	-0.65	0.17
LOT	-0.46	-0.16	0.06	-0.65	1.00	-0.03
ROLL	0.20	0.08	0.78	0.17	-0.03	1.00
1900	**AK1900**	**DER**	**GKN**	**LN(AK1900)**	**LOT**	**ROLL**
AK1900	1.00	0.47	-0.02	0.83	-0.39	-0.06
DER	0.47	1.00	-0.02	0.33	-0.10	0.02
GKN	-0.02	-0.02	1.00	-0.04	0.11	0.84
LN(AK1900)	0.83	0.33	-0.04	1.00	-0.56	-0.12
LOT	-0.39	-0.10	0.11	-0.56	1.00	0.32
ROLL	-0.06	0.02	0.84	-0.12	0.32	1.00
1910	**AK1910**	**DER**	**GKN**	**LN(AK1910)**	**LOT**	**ROLL**
AK1910	1.00	0.43	0.02	0.83	-0.27	0.04
DER	0.43	1.00	0.01	0.34	-0.06	0.03
GKN	0.02	0.01	1.00	0.05	0.17	0.98
LN(AK1910)	0.83	0.34	0.05	1.00	-0.41	0.08
LOT	-0.27	-0.06	0.17	-0.41	1.00	0.17
ROLL	0.04	0.03	0.98	0.08	0.17	1.00

Roll: spread measure according to Roll, $s_i^R = 2\sqrt{-\mathrm{cov}(r_{it}, r_{it-1})}$

GKN: spread measure according to George,Kaul, Nimalendran

LOT measure of transaction costs according to Lesmond, Ogden, Trczinka, $\overline{\alpha}_i - \underline{\alpha}_i$.

AK: book value

DER: debt-equity ratio

Figure 1: **Scatterplot of spread estimators according to**
Roll (1984) - left
GKN (1991) - center
LOT (1999) - right

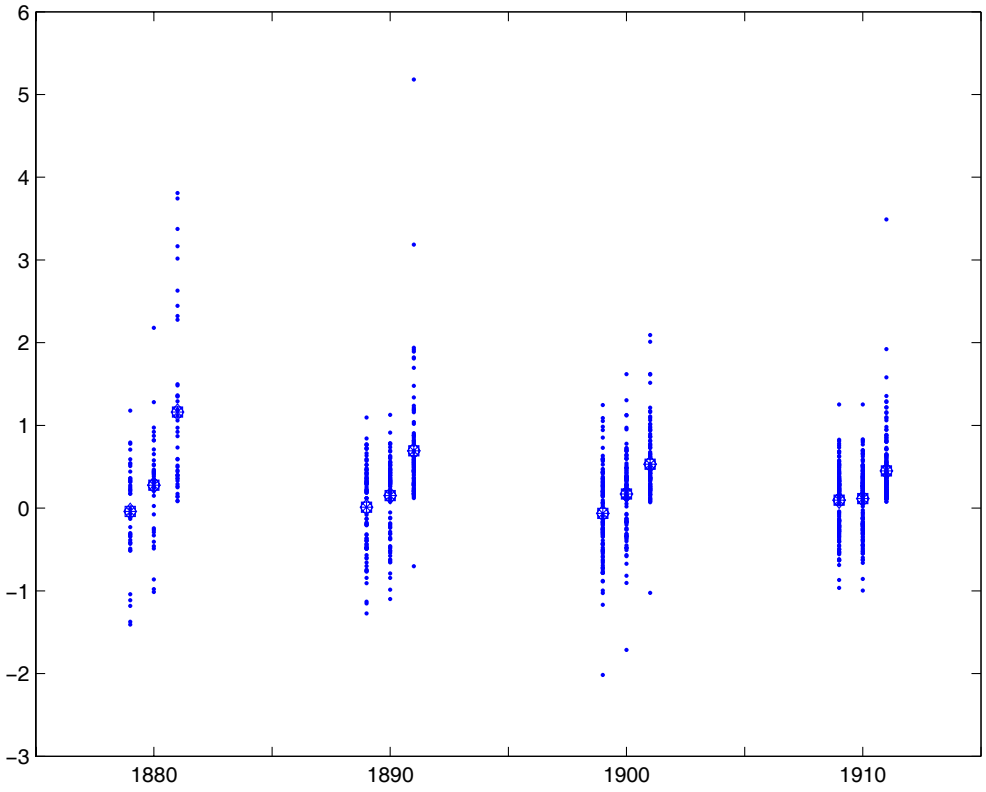

Figure 2: Various spread measures of the historical data

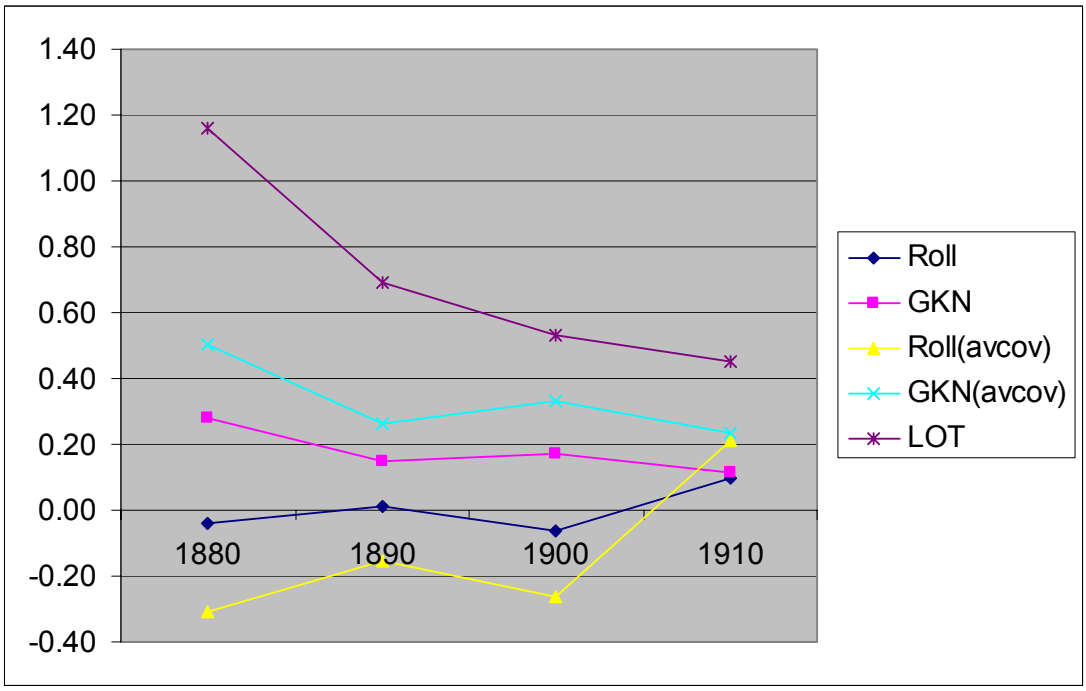

Figure 3: Various spread measures of the DAX

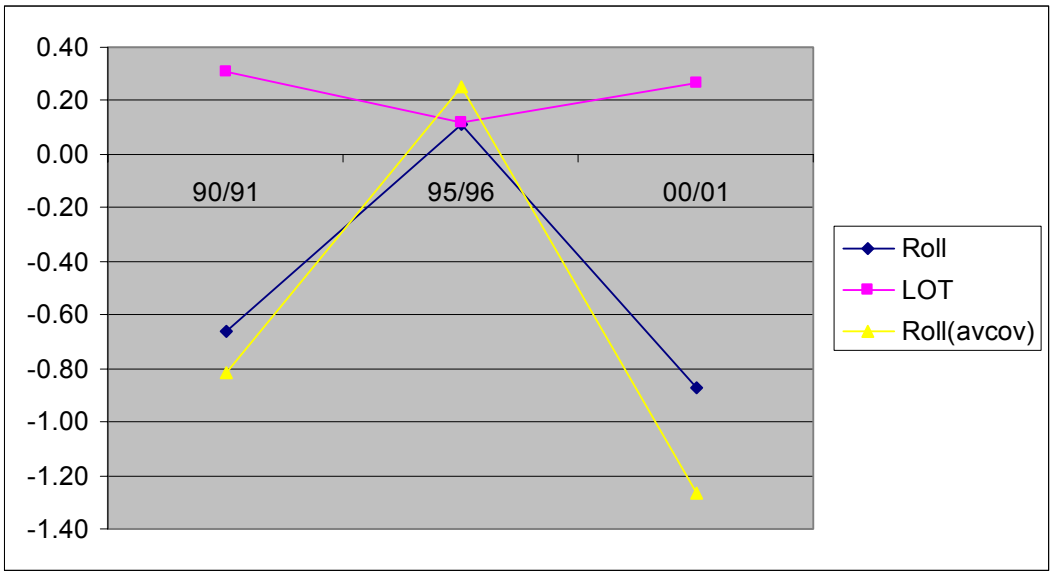

Figure 4: Various spread measures of the MDAX