Transaction costs, liquidity and expected returns at the Berlin Stock Exchange, 1892-1913♣

by

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Abstract:

We estimate effective spreads and round-trip transaction costs at the Berlin Stock Exchange for the period 1892-1913 using daily stock market returns for a sample of 27 stocks. Our results show that transaction costs at the main stock exchange in a bank-based financial system at the turn of the 20th century were quite low and about comparable to transaction costs in modern markets. Nonetheless, transaction costs varied substantially over time and across securities, whereby the cross-sectional variation could be substantially explained by firm size and previous year return, whereas time variation could be explained by crises and trading volume. Furthermore, we find evidence that expected transaction costs positively affect expected excess returns, whereas standard risk characteristics, such as market beta and size have no significant influence.

JEL-Classification:
G 12, G 14, N 23

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Transaction Costs; Effective spreads; Economic History; Germany

I. Introduction

High transaction costs on a security market are a sign of market inefficiency. For example, Jensen (1978) demonstrates that transaction costs can limit the ability of traders to profit from mispricing. Moreover, a plethora of papers starting with Amihud and Mendelson (1986) shows that high transaction costs increase the expected return on assets and thus reduce asset prices. Furthermore, Pagano (1989) proves the existence of equilibrium with high transaction costs, low trading activity, and high volatility as well as the existence of a Pareto-superior equilibrium with low transactions costs, high trading activity, and low volatility. In sum, high transaction costs reduce prices and increase volatility. By and large, the empirical literature based on modern data supports this view. For example, Asparouhova et al. (2010), Eleswarapu (1997) and Chalmers and Kadlec (1998) support the hypothesis of a positive risk premium for illiquidity; Baltagi et al. (2006) and Hau (2006) illustrate that higher transaction costs come along with higher volatility.

We estimate effective transaction costs on an early stock market located in a bank-based financial system: the Berlin Stock Exchange between 1892 and 1913. Therefore we make use of the measure first analyzed in Lesmond et al (1999). One would expect that effective spreads and transaction costs were comparatively high in this market for at least two reasons: first, technological progress during the last century – e.g., the introduction of electronic trading platforms – should have resulted into lower spreads and costs. Second, stock markets are supposed to be small and inefficient in the traditional German financial system. However, we show that transaction costs at the Berlin Stock Exchange a century ago were of about the same size as they are in modern financial markets. Our measure of transaction costs indicates that the cost for a roundtrip transaction were about 0.98 percent of the share price. This compares to an estimate of 1.23 percent for the largest decile of firm listed at the New York Stock Exchange for the period 1963-1990 (Lesmond et al., 1999).

This result fits well with recent empirical literature investigating Germany's early stock market history. According to the traditional view, Germany has had a bank-based financial system dominated by large joint-stock credit banks since the late 19th century (see Fohlin, 2007, chapters 1 and 2 for a review). However, recent research points to the significance and efficiency of the German stock market at the turn of the 20th century. First of all, Rajan and Zingales (2003) show that the ratio of stock market capitalisation over GDP and the number of listed corporations per million inhabitants was higher in Germany than in the U.S. in 1913. Moreover, the German stock market was not only deep, but also efficient: Weigt (2005: 199) and Baltzer (2006) show that stock price differentials among German stock exchanges and between the Berlin Stock Exchange and other major European stock exchanges were small; stock price differentials were arbitraged away. Furthermore, Weigt (2005: 224) demonstrates that stock prices reflected the risk and return characteristics of the shares quite well. In addition, Gelman and Burhop (2008) illustrate the weak information efficiency of the Berlin Stock Exchange. Furthermore, Gehrig and Fohlin (2006) estimate in a paper closely related to our work the effective spreads of samples of Berlin traded shares for the benchmark years 1880, 1890, 1900, and 1910.

Qualitatively, our findings are similar to the results presented by Gehrig and Fohlin (2006). We supplement their findings by showing that transaction costs vary substantially over time and across stocks. We can link the variation of transaction costs to crises and to the size of the company in the cross-section. Our findings suggest that transaction costs were particularly high during periods of financial distress, e.g., the 1901 banking crisis and the 1913 war-crisis, and for smaller (in support of Gehrig and Fohlin (2006)) and distressed enterprises. Moreover, we test whether transaction costs had a positive impact on expected returns, by including a transaction costs measure into CAPM and multifactor models. In line with literature, we find a significant positive premium for expected transaction costs. Thereby we find – in contrast to Weigt (2005) – that the CAPM does not hold for the period 1892-1913, whereas the size and momentum effects are present.

The remaining parts of the paper are organised as follows. In Section II, we give a short description of the Berlin Stock Exchange at the turn of the 20th century and we describe our data sources. Two measures of effective spreads and one measure of round-trip transaction costs are illustrated in Section III, along with brief description of implemented regression techniques. The results are presented in Section IV, followed by our conclusion in Section V.

II. Market Structure and Data Description

During the period of industrialisation, universal banks played a major role in the German economy: they facilitated its 'take-off', they provided loans to the modern industrial firms, and they monitored industrial corporations. Close bank-industry relationships ameliorated liquidity constraints of industrial firms and thereby made investment easier and supported industrial growth.[1] Nevertheless, bank loans were only one way to ensure the financing of an industrial enterprise. Self-financing of investments using retained profits was significant in Imperial Germany. Yet, by far the most important source of capital was equity. Share capital accounted for more than half of the assets of Germany's industrial corporations until World

[1] An excellent review of the literature is provided by Fohlin (2007).

War I (Fohlin, 2007: 174). These equities were issued at one of Germany's stock exchanges. By the early 1870s, the Berlin Stock Exchange was the main stock exchange in Germany with several hundred listed corporations. Until World War I, the number of Berlin-quoted companies increased to about 1,000.

Shares were traded at the Berlin Stock Exchange six days peer week using a call auction mechanism. Official brokers balanced purchase and sale orders and set the final binding price of all orders once a day. This ensured a high level of transparency at the Berlin Stock Exchange throughout the period considered here (Fohlin, 2007: 235). Turning to transactions costs, we may distinguish three types of observable costs: taxes, broker fees, and bank fees. Transactions at German stock exchanges were taxed from 1881 onwards. During this year, a stamp tax on stock market transaction at a fixed rate of 0.20 Mark per transaction was introduced. This tax was transformed into a percentage tax in 1885. More specifically for the period under consideration here, the stock market turnover tax was 0.01 percent of the underlying transaction value between 1892 and April 1894. From May 1894 onwards, the tax was doubled to 0.02 percent; another increase to 0.03 percent followed in October 1900. In addition to turnover taxes, the fees for brokers influence transaction costs. The fee for official brokers (*Kursmakler*) was 0.05 percent of the underlying transaction value, whereas the fee for private brokers (*Privatmakler*) was only 0.025 percent (Gelman and Burhop, 2008). Furthermore, provisions for the banks or other intermediaries varied between 0.1 and 0.33 percent (Weigt, 2005: 192). In sum, broker fees, provisions for intermediaries, and turnover taxes add up to a total cost for a roundtrip transaction (i.e., buying and selling of a share) in the range of 0.252 to 0.82 percent.

To investigate the size of effective spreads and transaction costs and to evaluate whether they changed over time, we use daily stock prices for the period 31 December 1891 to 31 December 1913 collected from the *Berliner Börsenzeitung* – Germany's leading financial daily of the pre-1913 period – for a sample of 27 continuously traded corporations from the Berlin stock exchange. The data were obtained from Gelman and Burhop (2008) who construct a daily stock market index for the period 1892-1913.[2] The sample contains 6,692 daily returns. The average daily return was 0.023 percent and they display distributional

[2] Starting point for the index construction was the collection of daily share prices from the *Berliner Börsenzeitung* for a sample of 39 continuously listed non-insurance corporations from the Berlin stock exchange. Insurance companies were excluded from the index since trading in them was heavily restricted. They only issued *vinkulierte Namensaktien*, registered shares with restricted transferability. Then securities with the portion of zero daily returns in the period under study of one third or higher were deleted from the index. 27 corporations remained.

properties similar to modern stock market returns. Descriptive statistics of individual stocks are shown in Table 1.

Table 1. Distributional properties of stock returns of the Gelman-Burhop-index constituent companies

	Name	Mean (ann.)	Median (ann.)	Max.	Min.	Std. Dev.	Skew-ness	Kur-tosis	Proportion of zero returns	ρ(1)	Average Market Cap. (mill M)
1	AG für Anilinfabrikation	0.0678	0.0000	0.1257	-0.2270	0.0082	-3.85	126.25	0.1638	0.0008	2727
2	Allgemeine Elektricitätsgesellschaft	0.0336	0.0000	0.0526	-0.0611	0.0065	-0.18	11.94	0.0807	0.0820	14997
3	Berlin-Anhaltinische Maschinenbau	0.0134	0.0000	0.1037	-0.0878	0.0078	-0.65	25.62	0.1540	-0.0474	1179
4	Bochumer Bergwerk (Lit C)	0.2457	0.0000	4.6522	-0.3611	0.0603	68.59	5285.9	0.2192	0.0060	351
5	Deutsche Bank	0.0294	0.0000	0.0333	-0.0544	0.0042	-1.64	24.72	0.1001	-0.0119	32778
6	Dresdner Bank	0.0129	0.0000	0.0446	-0.0554	0.0048	-0.85	17.74	0.1062	0.0230	19931
7	Darmstädter Bank (BHI)	0.0006	0.0000	0.0642	-0.0846	0.0044	-1.21	40.81	0.1903	-0.0231	16689
8	Deutsche Jute Spinnerei und Weberei	0.0465	0.0000	0.0674	-0.1040	0.0079	-0.53	16.89	0.2061	0.0024	430
9	Deutsche Spiegelglas	0.0687	0.0000	0.0921	-0.0838	0.0080	-0.30	18.32	0.1877	0.0716	643
10	Erdmannsdorfer Spinnerei	0.0001	0.0000	0.1143	-0.0774	0.0106	0.62	13.70	0.2497	-0.0425	286
11	Gelsenkirchener Bergwerksgesellschaft	0.0254	0.0000	0.0484	-0.0858	0.0071	-0.82	13.87	0.0555	0.0240	15580
12	Gerresheimer Glashütten	0.0480	0.0000	0.0739	-0.1208	0.0079	-1.61	33.11	0.2452	-0.0551	1112
13	Hallesche Maschinenfabriken	0.0266	0.0000	0.1000	-0.2788	0.0093	-6.04	169.13	0.1666	-0.0287	667
14	Harpener Bergbau AG	0.0212	0.0000	0.0668	-0.0682	0.0075	-0.28	11.77	0.0517	0.0282	10400
15	Kattowitzer AG für Bergbau und Eisen	0.0348	0.0000	0.0609	-0.0603	0.0068	-0.26	13.77	0.1313	0.0402	4652
16	Maschinenfabrik Kappel	0.0711	0.0000	0.2014	-0.2138	0.0113	-0.61	48.92	0.1725	0.0721	340
17	Norddeutsche Wollkämmerei	0.0192	0.0000	0.0738	-0.0838	0.0080	0.01	15.22	0.2025	0.0272	1926
18	Schaffhausen'scher Bankverein	0.0000	0.0000	0.0454	-0.0409	0.0037	0.07	22.24	0.2688	0.1121	14043
19	Oberschlesische Portland-Cement AG	0.0390	0.0000	0.1267	-0.0943	0.0098	0.72	23.25	0.1515	-0.0238	440

20	Rheinische Stahlwerke	0.0151	0.0000	0.1095	-0.1427	0.0085	-0.77	39.52	0.1230	-0.0337	3745
21	Rositzer Zuckerfabrik	0.0435	0.0000	0.0833	-0.0826	0.0092	0.05	11.73	0.1413	0.0237	717
22	Chemische Fabrik vormals Schering	0.0162	0.0000	0.0652	-0.0657	0.0083	0.17	10.17	0.1630	0.0610	1298
23	Schlesische Zinkhütten	0.0336	0.0000	0.1079	-0.0853	0.0066	-0.52	33.99	0.2360	-0.0582	7947
24	Schlesische Leinen-Industrie	-0.0043	0.0000	0.0703	-0.0679	0.0063	-0.56	21.28	0.3194	-0.1558	1015
25	Schultheiss Brauerei	0.0097	0.0000	0.0897	-0.0853	0.0057	-1.23	65.22	0.1714	-0.2016	2522
26	Siemens Glas-Industrie	0.0287	0.0000	0.0438	-0.0576	0.0058	-1.12	19.17	0.1966	-0.0273	2290
27	Stettiner Chamottewaren	-0.0096	0.0000	0.0804	-0.2538	0.0088	-3.85	126.25	0.1452	0.0281	2640
	Gelman-Burhop index	0.0687	0.0909	0.0296	-0.0562	0.0032	-1.68	30.78	n/a	0.165	161344
	Equally-weighted price index	0.0327	0.0600	0.1780	-0.0325	0.0036	17.80	913.90	n/a	0.167	161344

Notes: Mean and median returns are presented on the annual basis (mean daily return x300) for illustrative purposes.

III. Econometric technique

In an information-efficient stock market, prices of stocks should incorporate new information instantaneously. However on the real-world stock exchanges the presence of transaction costs induces some deviations from such behaviour. Uncovering these deviations and analyzing them allows tracking back full transaction costs.

This idea is exploited in a measure of transaction costs, proposed by Lesmond et al. (1999). The LOT measure reflects the total costs of a roundtrip transaction, which includes not only the difference between bid and ask prices, but also all further expenses carried by the trader, including the price change induced by the trade itself (so called price impact, see Lesmond 2005). The LOT measure is based on the idea that transactions will only occur if the deviation of the market price from the true value of a stock is larger than the costs of a transaction. Thus, there are upper and lower thresholds – τ_i^l and τ_i^h – such that the measured return r is non-zero only if the true return exceeds the threshold:

$$\text{(4a)}\quad r_{i,t} = R_{it}^* - \tau_i^l \text{ if } r_{i,t}^* < \tau_i^l$$
$$\text{(4b)}\quad r_{i,t} = 0 \text{ if } \tau_i^l < r_{i,t}^* < \tau_i^h$$
$$\text{(4c)}\quad r_{i,t} = R_{it}^* - \tau_i^h \text{ if } r_{i,t}^* > \tau_i^h.$$

Thereby the true return depends on the market return $r_{m,t}$ in a linear way: $r^*_{i,t} = \beta_i r_{m,t} + e_{i,t}$.

The estimated difference between the upper and the lower threshold – i.e. τ_i^h less τ_i^l – is a measure of the roundtrip transaction costs.

We use the following maximum likelihood estimator, developed by Lesmond et al. (1999), to estimate the LOT measure:

$$L\left(\tau_i^l, \tau_i^h, \beta_i, \sigma_i \middle| r_{it}, r_{mt}\right) = \prod_1 \frac{1}{\sigma_i}\phi\left[\frac{r_{it} + \tau_i^l - \beta_i r_{mt}}{\sigma_i}\right] \times \prod_0 \left[\Phi\left(\frac{\tau_i^h - \beta_i r_{mt}}{\sigma_i}\right) - \Phi\left(\frac{\tau_i^l - \beta_i r_{mt}}{\sigma_i}\right)\right]$$
$$\text{(5)} \times \prod_2 \frac{1}{\sigma_i}\phi\left[\frac{r_{it} + \tau_i^h - \beta_i r_{mt}}{\sigma_i}\right]$$
$$\text{S.T. } \tau_i^l \le 0, \tau_i^h \ge 0, \beta_i \ge 0, \sigma_i \ge 0,$$

Where Φ() is the standard normal cumulative distribution function. Thereby region 1 (indicated by "1" below the Π) corresponds to the negative expected latent variable when the observed is nonzero ($\hat{r}_{it}^* < 0$, or equivalently $r_{mt}<0$ and $r_{it} \neq 0$), region 2 – to the positive expected latent variable if observed is nonzero (r_{mt}>0 and $r_{it} \neq 0$) and region 0 corresponds to the observation with zero observed returns ($r_{it} = 0$). σ_i denotes the root out of the residual variance, measured over non-zero returns region.

The LOT measure thus includes the bid-ask spread, commissions, transaction taxes, costs of information acquirement and processing as well as price impact. Its size should be therefore larger than the regulated costs, i.e., the sum of broker fees, provisions, and transaction taxes.

However, the precision of this transaction cost estimate relies on the explanatory power of market model for stock returns. Thus, if further information sources or factors, such as returns on Fama-French (1993) SMB and HML factor portfolios have significant influence on individual stock returns, effective transaction costs may be substantially under- or overestimated.[3] Yet, since the LOT-measure proved to be a good proxy for transaction costs in modern financial markets (see Goyenko et al. 2009, Lesmond 2005) we see it as justified to use for the historical data in our study.

As we find considerable differences in transaction costs across companies, similar to Gehrig and Fohlin (2006), we run cross-section regressions of estimated average transaction costs on a set of explanatory variables:

$$(6)\ \bar{S}_i = \alpha + \beta' X_i + \varepsilon_i,$$

where X denotes a vector of explanatory variables and β a vector of corresponding coefficients. However, as we observe remarkable time variation of transaction cost estimates we also run a panel regression:

$$(7)\ S_{it} = \alpha + \beta' X_{it} + \mu_i + \lambda_t + v_{it},$$

where μ_i denote cross-sectional individual effects, λ_t denote period effects and v_{it} is an idiosyncratic error term.

We rely on the standard technique in the asset pricing literature, the Fama-MacBeth (1973) regression, when analyzing the impact of transaction costs on the cross-sectional variation of returns. It is based on the assumption, that expected returns of stocks are fully described by the linear combination of risk premia and factor loadings for all relevant factors:

$$E[Z_i] = \boldsymbol{\lambda}' B_i,$$

whereby $Z_{it} = r_{it} - r_{ft}$ denotes excess return, $\boldsymbol{\lambda}'$ is a transposed vector of risk-premia and B_i is a vector of factor loadings or risk characteristics of company *i*. Given the values of factor loadings for each stock in each period the risk premia are estimated running *T* cross-section regressions (one for each period) and averaging the estimates:

[3] We are grateful to Christian Julliard for this comment.

$$Z_{it} = \boldsymbol{\lambda}_t' B_{it}$$

$$\overline{\boldsymbol{\lambda}} = \frac{1}{T}\sum_{t=1}^{T} \hat{\boldsymbol{\lambda}}_t$$

The corresponding standard errors for each *k*-th element of the risk-premia vector are calculated from the corrected time variance of the estimated premia:

$$\mathrm{var}\left[\lambda_{kt}\right] = \frac{1}{T}\sum_{t=1}^{T}\left(\hat{\lambda}_{kt} - \overline{\lambda}_k\right)^2$$

$$\mathrm{stderr}\left[\overline{\lambda}_k\right] = \sqrt{\mathrm{var}\left[\lambda_{kt}\right]\cdot\left(1 + \frac{\overline{z}_{mt}^{\,2}}{\mathrm{var}\left[z_{mt}\right]}\right)\Big/ T}\,,$$

where z_{mt} denotes the excess return of the market index. For the risk factor *k* to be priced the corresponding risk premium should be significantly different from zero.

IV. Results

Table 2 presents the annual averages over all trading days and all shares for each measure as well as the average for the full sample period 1892-1913.

TABLE 2: ANNUAL AVERAGE OF TRANSACTION COSTS

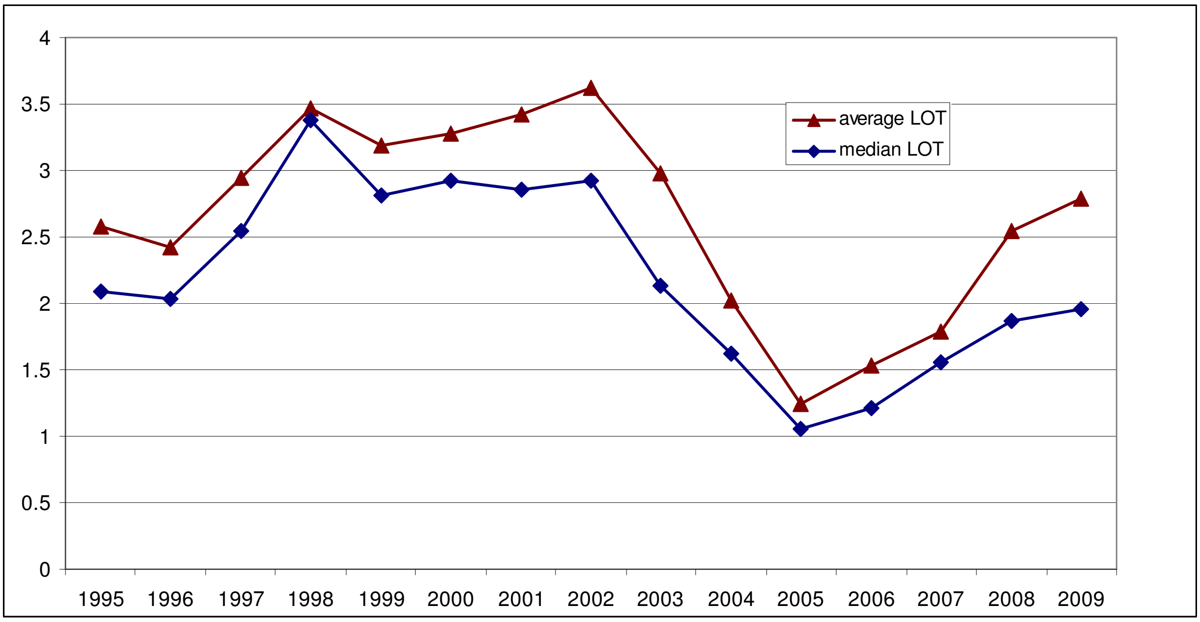
Year	LOT	Std. error	95% confidence interval	
			lower bound	upper bound
1892	1.454	0.062	1.333	1.575
1893	1.584	0.067	1.452	1.716
1894	1.072	0.050	0.975	1.169
1895	0.925	0.046	0.835	1.015
1896	0.805	0.039	0.729	0.881
1897	0.814	0.041	0.735	0.893
1898	0.908	0.044	0.821	0.995
1899	0.878	0.045	0.789	0.967
1900	1.029	0.057	0.917	1.141
1901	1.678	0.073	1.534	1.822
1902	0.977	0.224	0.537	1.417
1903	0.848	0.040	0.769	0.927
1904	0.825	0.041	0.744	0.906
1905	0.696	0.036	0.625	0.767
1906	0.658	0.034	0.591	0.725
1907	0.775	0.042	0.693	0.857
1908	0.846	0.045	0.757	0.935
1909	0.731	0.040	0.653	0.809
1910	1.039	0.046	0.949	1.129
1911	0.713	0.036	0.642	0.784
1912	0.883	0.044	0.797	0.969
1913	1.124	0.049	1.028	1.220
Average	0.966	0.012	0.942	0.990

Own calculations based on daily returns for 27 stocks for the period 1892-1913. Expressed in percent of share price, equally weighted averages. Four outliers were dropped. Standard errors are calculated taking into account cross-correlations between stocks (see Appendix XX). Confidence interval is given by $\overline{S}_{LOT,t} \pm 1.96 s.e.\left(\overline{S}_{LOT,t}\right)$

According to the LOT measure, the transaction costs at the Berlin Stock Exchange varied between 0.66 percent (in 1906) and 1.68 percent (in 1901). The transaction costs were positive for any randomly chosen yearly period and always higher than the lower bound of the regulated fees. The average transaction costs amounted to 0.97 percent. Therefore, we broadly confirm the result presented by Gehrig and Fohlin (2006), who estimated an average LOT measure of 0.71 percent for the four benchmark years 1880, 1890, 1900, and 1910.

Compared to modern data, it may come as a surprise that transaction costs were rather stable at the German stock exchange over the last century. We find that the 27 companies under study at the turn of the twentieth century had, on average, lower transaction costs than the 2nd tier German blue chips at the turn of the twenty-first century: Applying the same technique to 47 MDAX companies for 1995-2009 yields average and median LOT measures of 2.6 percent and 2.1 percent. Interestingly, we observe that the annual average transaction costs for the crisis years 1998 and 2000/2001 are with 3.3-3.5 percent clearly above the overall sample mean.

Figure 2. Annual LOT measures for MDAX companies



Notes: Estimates of transaction cost measures according to LOT (1999) – equations (4a)-(4c) for each year. Equally weighted averages and medians over 47 stocks belonging to MDAX index.

Evidence for other modern stock markets supports the impression that transactions costs were quite low at the Berlin Stock Exchange already a century ago. Goyenko et al. (2009) document LOT measures for Dow Jones Industrial Average index of 0.6 percent in mid 1970s and 1980s which is comparable to our results for the Berlin Stock Exchange index in mid 1900s. Very advantageous is the comparison to the modern emerging markets: stocks in the Gelman-Burhop (2008) index have lower transaction costs according to the LOT measure than any of the 31 emerging markets in the 1990s, covered in the study of Lesmond (2005): their average transaction costs range from 2.3 percent for Taiwan to 18 percent for Russia. Some, but not all, of this reported superiority of Berlin Stock Exchange at the turn of the 20th century can be explained by broader sample of securities pro country, analyzed in Lesmond (2005).

Additional insights provide inter-company differences in transaction costs (see Appendix 1). Whereas textile companies, such as Deutsche Jute Spinnerei und Weberei and Erdmannsdorfer Spinnerei report LOT measures of (1.1 percent) and (1.7 percent) which could be found also for median Chinese stock (compare Lesmond 2005), the transaction costs of banking sector stocks like Deutsche Bank (0.38 percent) and Dresdner Bank (0.45 percent) is on the same level with Dow Jones companies in 1980s and 1990s (compare Goyenko et al. 2009). These deviations however, cannot be attributed fully to industrial differentiation: companies included into the index stemming from the banking sector have much higher market capitalization, e.g. the value of Deutsche Bank was on average 114 times the value of Erdmannsdorfer Spinnerei.

The explanation may rather have informational origins: assuming the same share of trading relative to market capitalization across companies, the volume of trade for large companies was higher, allowing market makers to incorporate new information. Furthermore, large companies had probably better analyst coverage, providing more thorough information to investors, thus decreasing information asymmetry and providing for lower transaction costs.

Some evidence for this hypothesis can be obtained from a simple cross section regression of average transaction costs on the log of the market capitalization. However, one should be cautious as Amihud and Mendelson (1986) reveal the possibility of a reversed causal relationship: transaction costs can raise expected returns and thus reduce the market capitalization of a company. To avoid the endogeneity problem and to ensure the pre-determinacy we use the market capitalization of 1892 (which is measured at the beginning of the year) to explain company transaction costs averaged over the twenty-two year sample. For the twenty-six companies we obtain (standard errors of estimates are in parenthesis):[4]

$$\begin{aligned} \overline{S_i^{LOT}} &= \underset{(0.62)}{4.92} - \underset{(0.03)}{0.19} \cdot \ln\left(MC_i^{1892}\right) + \hat{e}_i, \\ R^2 &= 0.64, \qquad \hat{e}_i \approx \left(0, 0.20^2\right) \end{aligned} \tag{8}$$

All estimates are highly significant and support the hypothesis that market capitalization decreases transaction costs: raising the market capitalization by 2.3 bln Mark (what corresponds to a one unit change of log market capitalization at the mean of the variable)

[4] We exclude Bochumer Bergwerk henceforth from the analysis, as it has unusually high transaction costs due to several months long periods of non-trading.

leads to a 0.19 percentage points narrower spread. Interestingly, our coefficient coincides with the one reported by Gehrig and Fohlin (2006) for the year 1900 for the log of the book value and is considerably close to their results for 1890 and 1910. Thereby market capitalization explains almost two thirds of the inter-company transaction cost variation in our sample.

Another issue possibly relevant for transaction costs is tick size, which was 0.05 RM. Thus, our transaction costs measure expressed in percent of the price should be higher for stocks with lower value. However, including the (log) price level at the beginning of the sample does not significantly help to explain the cross-section of transaction costs:

$$\begin{aligned} &\overline{S_i^{LOT}} = \underset{(0.80)}{5.15} - \underset{(0.03)}{0.19} \cdot \ln\left(MC_i^{1892}\right) - \underset{(0.11)}{0.05} \ln\left(P_i^{1892}\right) + \hat{e}_i, \\ &R^2 = 0.64, \qquad \hat{e}_i \approx \left(0, 0.20^2\right) \end{aligned} \tag{9}$$

While other coefficients barely change, the coefficient in front of the log price level is of a correct sign, though insignificant. Possibly, given that prices fluctuate considerably during the 22 ear period, using the first year results could be insufficient to uncover the relationship.

Therefore, we run regressions of transaction costs on market capitalization and on both market capitalization and price level in a balanced panel set-up with individual effects. We assume that trade volume is proportional to market capitalization not only across companies but also across time. If higher trade volume of larger firms is associated with lower transactions costs, then we should find the same relationship in the panel regression as in the cross section regressions (8) and (9).

However, as market capitalization is clearly non-stationary over the 22 year sample, we use the fraction of the overall market capitalization contributed by each company. Therefore, we have to include time-effects to account for changes in the overall market capitalization. Moreover, due to withholding of the transaction cost there is data on aggregate annual trade volume of all stocks in German Empire, which can be used instead of time effects.

In order to treat the non-stationarity of log price levels we take first differences and obtain returns (neglecting dividends).

To address the endogeneity problem we use lagged log price changes. Since market capitalization is reported for the beginning of each year, we do not face possible reverse causality.

We perform random effects and fixed effects estimations. The result of the Hausman test allows using random effects. Since the between variance of the market capitalization variable constitutes about 96% of the overall variance of this explanatory variable, we report also random effects estimation results for the fully specified model.

Table 3. Panel regression results

	(1) FE	(2) FE	(3) FE	(4) FE	(5) RE	(6) GMM
Constant	1.00*** (0.06)	0.96*** (0.05)	0.94*** (0.07)	1.79*** (0.19)	1.85*** (0.20)	
S_{it-1}						0.44*** (0.01)
$MC_{it}/\sum MC_{it}$	-3.12** (1.57)	-2.59** (1.19)	-2.59 (1.91)	-2.58 (1.59)	-4.29*** (0.73)	-0.28 (1.50)
ΔlnP_{it-1}		-0.25 (0.16)	-0.34** (0.16)	-0.45*** (0.16)	-0.44*** (0.16)	-0.11*** (0.04)
$lnTV_t$				-0.20*** (0.05)	-0.20*** (0.05)	-0.22*** (0.01)
t_{1901}			0.26*** (0.08)			
t_{1913}			0.25*** (0.07)			
Time effects	Y	Y	N	N	N	N
R^2	0.56	0.60	0.48	0.46	0.27	

Estimates of LS fixed effects models for the transaction costs (LOT measures) for the sample period from 1892 to 1913 for the panel of 26 companies of the type: $S_{it} = \alpha + \beta' X_{it} + \mu_i (+\lambda_t) + v_{it}$. White period standard errors are reported in parenthesis. Values marked with ***, ** and * are significant at 1%, 5% and 10% level respectively. R^2 is calculated as one minus the fraction of the residual variance to the variance of the dependent variable.

Column 1 in Table 3 supports the size hypothesis: negative coefficients in the regressions with fixed effects indicate that if the share of market capitalization in the index increases by one standard deviation (5 percentage points) transaction costs decrease by 0.16 percentage points. Some loss in statistical significance – now the impact of market capitalization is significant only on the 5% level opposed to the 1% level in cross-section – is probably due to a much smaller variability of the variable in time.

Previous year log price changes have a negative impact on transaction costs, which is significant in all specifications without time-effects (columns 3-6 of Table 3). This result supports the findings of Griffin et al. (2004) and Bekaert et al. (2007), who find that returns help predict liquidity on modern financial markets.

Furthermore, time effects play a substantial role: they explain about 15 percent of the transaction costs variation. About one-seventh of the explanatory power of time can be attributed to two years: 1901 and 1913 (see column 3) – which are known to have caused worsening information efficiency (Gelman and Burhop 2008). In 1901 the bankruptcy of Leipziger Bank, one of Germany's largest banks, caused a stock exchange turmoil and possibly high degree of uncertainty about fair prices of shares which forced speculative traders to act more conservative, thus increasing transaction costs. In 1913, the fear of a Balkan war led to similar effects on the financial market.

The log of the German stock trading volume (see columns 4-6 of Table 3) picks up only about 1% of the variance of transaction costs (thus explaining only $1/15^{th}$ of time effects), but is highly significant and the relationship seems to be stable to different specifications.

About 16 percent is explained by cross-sectional individual effects.

Our main result – negative correlation of transaction costs with size – proves to be rather stable over time: An equivalent to column 1 panel regression of transaction costs of 47 MDAX stocks over 1999-2009 on the fraction of overall market capitalization yields a coefficient of -5.34, which is also significant on the 10% level and explains about 6% of the variation of transaction costs.[5]

The large dispersion of transaction costs should be revealed in asset pricing. As Amihud and Mendelson (1986) noted, given the set of investment opportunities, investors should avoid assets which have lower liquidity yielding same returns. This should in the long run decrease the price of such securities and raise their return. Therefore, in the long run one should find a positive relation between transaction costs and expected returns in the cross-section.

Here we analyze excess returns, calculated as total returns (price changes plus dividends) less the risk free rate. Including dividends is important as the companies may compensate investors with higher dividends for lower prices. In line with asset pricing literature, we use monthly data. We run Fama-MacBeth (1973) regressions for the traditional CAPM and several multifactor extensions, including transaction costs, and other popular characteristics – namely size and momentum.

As the risk free rate proxy we use the money market rate obtained from NBER (series: 13018). Size is the log of market capitalization and varies on the annual basis. Transaction costs are our LOT estimates, which also vary yearly. Market betas and momentum, the latter calculated as the first-order autocorrelation coefficient of daily price percentage changes, are

[5] Results available on demand.

constant for each company throughout the sample. We also include a constant as we do not demean the explanatory variables.

Table 4. Results of cross-section regressions for the whole sample 1/1892-12/1913

	(1)	(2)	(3)	(4)
Constant	.0018 (.0014)	-.0024 (.0021)	.0024 (.0107)	.0034 (.0108)
Market beta $\overline{\lambda}_{\beta}$	-.0003 (.0019)	.0016 (.0020)	.0013 (.0021)	-.0001 (.0022)
Transaction cost lagged $\overline{\lambda}'_{TC}$		.3266** (.1324)	.3068* (.1773)	.3055* (.1771)
Size $\overline{\lambda}_{S}$			-.0002 (.0004)	-.0002 (.0004)
Momentum $\overline{\lambda}_{M}$				.0105* (.0058)
Average R^2	0.07	0.12	0.16	0.20
# of stocks	26	26	26	26
# of cross-sections T	264	252	252	252

Estimates of the Fama-MacBeth (1973) regressions for the sample period from 1892 to 1913 for 26 companies. Reported coefficient values $\overline{\lambda}_k$ are averages of 264 (252 for columns (2)-(4)) regression estimates of the type: $Z_{it} = \alpha_t + \lambda_t' B_{it} + u_i$, where λ_t' denotes the transposed vector of risk premia and B_{it} denotes the vector of risk factor loadings, which serve as explanatory variables in each cross section. Standard errors are calculated as $\sqrt{\mathrm{var}[\lambda_{kt}] \cdot \left(1 + \frac{\overline{z}_{mt}^{\,2}}{\mathrm{var}[z_{mt}]}\right) \Big/ T}$, according to the Fama-MacBeth (1973) procedure with Shanken (1992) correction, and are reported in parenthesis. Values marked with ***, ** and * are significant at 1%, 5% and 10% level respectively. Average R^2 is an arithmetic mean of R^2 for each cross-section.

Our results in Table 4 reveal that CAPM does not hold for our sample in 1892-1913: the market risk premium is insignificant in all four specifications; moreover in two cases it has a wrong sign.

The premium for transaction costs in a two-factor model (column 2) is significant and positive, as expected. Statistical significance deteriorates a bit when adding size and momentum characteristics (columns 3-4).

Both specifications containing size (columns 3-4) provide very weak support for the small size premium, as the coefficients are negative, but absolutely insignificant. Seemingly, size to a large extent proxies liquidity risk, which is much better captured here by transaction costs.
The risk premium for momentum is significant and positive (see column 4): stocks, which daily price percentage changes are positively autocorrelated have on average higher expected returns.
Summarizing our results on impact of transaction costs on asset pricing, we find significant positive influence of round-trip transaction costs on expected returns. Thereby it seems to be the most pronounced determinant of the cross-section of stock returns, as market risk turns out to be insignificant, as well as size characteristics. Momentum premium has the expected sign and is significant on the 10% level.

V. Conclusion

Transaction costs at the Berlin Stock Exchange averaged about one percent between 1892 and 1913 according to the measure proposed by Lesmond et al. (1999). Thus, transaction costs a century ago were quite similar to today's cost. This may be surprising in the light of the traditional view of Germany as a bank-based financial system with underdeveloped security markets. However, recent empirical research shows that the German stock market was relatively deep during the pre-1913 period (Rajan and Zingales, 2003), weakly information efficient (Gelman and Burhop, 2008), and integrated with other German and European financial markets (Weigt, 2005; Baltzer, 2006). Consequently, low transaction costs – which were already reported by Weigt (2005: 198) and Gehrig and Fohlin (2006) – fit well into the picture of an efficient security market during Germany's industrialisation.
We discover also a high variation of transaction costs. The latter can be explained by size of the stock and period uncertainty: we find a negative relation between market capitalization and estimated transactions costs (supporting Gehrig and Fohlin 2006) as well as higher transaction costs in the crisis years 1901 and 1913. Moreover, transaction costs grow after negative returns.
Studying the impact of transaction costs on the cross-section of expected returns we find a significant positive relationship. Moreover, it seems to be the main driving force of the cross-sectional variance of returns, showing the extreme importance of liquidity risk at that time.

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Appendix 1: Average transaction costs of corporations, included in the investigation

Number	Name	Average LOT measure	Standard error	95% confidence interval	
				Lower	upper
1	AG für Anilinfabrikation	0.943	0.026	0.892	0.994
2	Allgemeine Elektricitätsgesellschaft	0.520	0.020	0.482	0.558
3	Berlin-Anhaltinische Maschinenbau	0.902	0.025	0.854	0.950
4	Bochumer Bergwerk (Lit C)	3.164	0.269	2.637	3.691
5	Bank für Handel und Industrie	0.543	0.014	0.516	0.570
6	Deutsche Bank	0.384	0.016	0.353	0.415
7	Dresdner Bank	0.446	0.015	0.417	0.475
8	Deutsche Jute Spinnerei und Weberei	1.109	0.025	1.060	1.158
9	Deutsche Spiegelglas	1.097	0.027	1.045	1.149
10	Erdmannsdorfer Spinnerei	1.689	0.035	1.621	1.757
11	Gelsenkirchener Bergwerksgesellschaft	0.427	0.021	0.387	0.467
12	Gerresheimer Glashütten	1.284	0.029	1.228	1.340
13	Hallesche Maschinenfabriken	1.112	0.029	1.054	1.170
14	Harpener Bergbau AG	0.425	0.022	0.383	0.467
15	Kattowitzer AG für Bergbau und Eisen	0.667	0.020	0.627	0.707
16	Maschinenfabrik Kappel	1.239	0.033	1.174	1.304
17	Norddeutsche Wollkämmerei	1.135	0.028	1.081	1.189
18	Oberschlesische Portland-Cement AG	1.094	0.013	1.069	1.119
19	Rheinische Stahlwerke	0.781	0.030	0.723	0.839
20	Rositzer Zuckerfabrik	1.053	0.025	1.005	1.101
21	Schaaffhausen'scher Bankverein	0.572	0.028	0.518	0.626
22	Chemische Fabrik vormals Schering	1.001	0.025	0.952	1.050
23	Schlesische Zinkhütten	0.959	0.022	0.916	1.002
24	Schlesische Leinen-Industrie	1.183	0.022	1.139	1.227
25	Schultheiss Brauerei	0.684	0.018	0.650	0.718
26	Siemens Glas-Industrie	0.776	0.018	0.740	0.812
27	Stettiner Chamottewaren	0.905	0.027	0.852	0.958

Source: Gelman and Burhop (2008), own calculations. Standard errors are calculated assuming independence of transaction cost estimates across time.

Table II

Number	Name	Average R-squared
1	AG für Anilinfabrikation	0.092322
2	Allgemeine Elektricitätsgesellschaft	0.329350
3	Berlin-Anhaltinische Maschinenbau	0.116825
4	Bochumer Bergwerk (Lit C)	0.065104
5	Bank für Handel und Industrie	0.351353
6	Deutsche Bank	0.397444
7	Dresdner Bank	0.488626
8	Deutsche Jute Spinnerei und Weberei	0.073646
9	Deutsche Spiegelglas	0.051038
10	Erdmannsdorfer Spinnerei	0.030019
11	Gelsenkirchener Bergwerksgesellschaft	0.508946
12	Gerresheimer Glashütten	0.054653
13	Hallesche Maschinenfabriken	0.043489
14	Harpener Bergbau AG	0.462738
15	Kattowitzer AG für Bergbau und Eisen	0.192785
16	Maschinenfabrik Kappel	0.043751
17	Norddeutsche Wollkämmerei	0.057130
18	Oberschlesische Portland-Cement AG	0.096344
19	Rheinische Stahlwerke	0.264628
20	Rositzer Zuckerfabrik	0.269807
21	Schaaffhausen'scher Bankverein	0.065095
22	Chemische Fabrik vormals Schering	0.072648
23	Schlesische Zinkhütten	0.089340
24	Schlesische Leinen-Industrie	0.010887
25	Schultheiss Brauerei	0.043544
26	Siemens Glas-Industrie	0.054630
27	Stettiner Chamottewaren	0.105594
	Average	**0.164138**

Numbers in the third column represent for each stock averages of 22 R-squared values obtained from yearly market model regressions for non-zero return observations.