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The Berlin Stock Exchange in Imperial Germany: A Market for New Technology?[†]

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Analyzing 474 cases of firms going public in the German capital between 1892 and 1913, we show that innovative firms could rely on the Berlin stock market as a source of financing. Our data also reveal that initial public offerings (IPO) of innovative firms were characterized by particularly low underpricing, comparatively high first trading prices, and no long-run underperformance. We interpret these empirical results as evidence for the surprising fact that in the period of the Second Industrial Revolution the Berlin stock exchange was already a well-functioning market for new technology.
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Attempting to imitate the successful American technology exchange, NASDAQ, in 1997 Germany introduced the so-called *Neuer Markt* (new market). This new stock exchange aimed to give young firms of sunrise industries, such as IT, telecommunication, and biotechnology, the ability to raise the equity capital needed to finance innovative projects. In June 2003, however, the bursting new-economy bubble forced the *Neuer Markt* closure. The *Neuer Markt* experiment was motivated by the argument that market-based financial systems have a relative advantage compared to bank-based ones when it comes to financing innovation (Levine 2002). This discussion usually stresses the contrast between German and American financial systems: the former apparently dominated by universal banks, the latter based on a well-developed stock market (Calomiris 1995). US success in new industries—such as automobiles, computers, semiconductors, or biotechnology—in the last two centuries has led many researchers to conclude that market-based financial systems excel at financing new technologies.

Germany's development in the late nineteenth century, however, raises serious doubts about the general validity of this hypothesis. Even though Germany is

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considered to be the classic example of a country with a bank-based financial system (Gerschenkron 1962), its firms still outrivaled most of their foreign competitors in the new and innovative industries of the Second Industrial Revolution, such as chemicals and electrical engineering. This contradiction can be resolved by either one of the following explanations. First, the theoretical distinction between bank-based and market-based financial systems might not matter in practice. Fohlin (2016, p. 426), for example, claims that the existence of some kind of well-functioning financial system is much more important for innovation and economic growth than the particular type of financial system. Second, the countries' financial systems might have been more similar than the stylized facts suggest. Fear and Kobrack (2010) argue that both the United States and Germany had rather similar hybrid bank-based and market-based financial systems before the First World War, in which banks served as important gatekeepers to stock exchanges. Our study supports the latter view.

Analyzing all 474 cases of firms that went public in the German capital, Berlin, between 1892 and 1913, we provide strongly suggestive evidence that innovative firms relied more than non-innovative firms on the Berlin stock market as a source of financing and therefore probably depended less on bank credit. In particular, our data imply that the firms' innovation activities significantly increased after the firms went public, suggesting that the Berlin stock exchange in fact mattered if innovative firms wanted to overcome their liquidity constraints. Another surprising observation is that initial public offerings (IPO) of firms with many future patents were characterized both by particularly low initial returns and by comparatively high first trading prices. We interpret these empirical results as evidence for the capacity of contemporary investors to identify firms with long-term innovativeness at the first day of trading. In contrast to the *Neuer Markt* of the late twentieth century, Imperial Germany's stock exchange was arguably a well-functioning market for new technology.

The literature presents various theoretical reasons that explain a market-based financial system's comparative advantage in financing new technology. Black and Gilson (1998) claim that well-developed stock markets provide an easy exit for venture capitalists and therefore increase their willingness to invest in unknown innovative startups. Allen and Gale (2000) stress the informational advantages of market-based financial systems. In contrast to a bank-based financial system in which a comparatively small number of bank managers with limited knowledge of innovation make the most of investment decisions, a market-based financial system utilizes widespread information. The stock market allows everybody to contribute or withhold capital according to his or her own subjective expectations. That is why some innovative projects might attract sufficient financial means in market-based systems, but would fail in financial systems dominated by conservative bank managers. According to Levine (2002, p. 400), the latter might even have incentive to suppress some innovations in order to protect their long-term customers from newly arising competition.

Several historical case studies imply that nineteenth century German universal banks were in fact rather reluctant to finance the establishment of new and potentially innovative firms, but dealt mostly with well-established companies in traditional industries such as iron and steel (Hahn 1958; Pierenkemper 1990; Feldenkirchen 1991). According to Neuburger and Stokes (1974), the banks' focus on mature

industries slowed down German economic growth considerably because it deprived innovative firms in the new industries of chemicals and electrical engineering of capital. As a result, despite a well-developed banking sector,[1] German entrepreneurs might have been forced to finance innovation mainly from their own resources, i.e., from private wealth or previous profits.

Quantitative studies support the assumption that universal banks played only a minor role in Germany's high industrialization. Fohlin (2007, p. 104) failed to identify any causal relationship between banking and economic growth in the period 1895 to 1913. Burhop (2006) extends the period by analyzing the relationship between financial depth (total assets of banks/net national product) and Germany's economic performance between 1851 and 1913. For the period 1851 to 1882, Burhop confirms Gerschenkron's bank-led growth hypothesis: the growth of the joint-stock banks' financial depth had a positive and significant impact on economic performance in Germany. For the period 1883 to 1913, however, Burhop's results are in line with Fohlin's negative findings: the joint-stock banks lost their statistically significant impact on economic growth during Germany's high industrialization.[2] On the basis of a small sample of corporations, Franks, Mayer, and Wagner (2006, p. 559) show that, around the year 1900, German firms financed up to two-thirds of their assets by issued equity (and another 15 percent by internal reserves) and only about 10 percent by bank credits.

The question remains whether this macroeconomic shift from debt to equity also opened up new opportunities for innovative firms that had apparently found it too hard to access finance from traditional bank loans. Qualitative evidence shows that many firms assumed that patents could serve as a positive signal that increased the attractiveness of their shares. The *Salinger Börsenhandbuch*, a widely used stock market manual that provided information on existing joint-stock companies, often republished details of firm-specific patent portfolios the companies themselves had already revealed when advertising their IPOs in listing prospectuses. In 1904, for example, the *Salinger Börsenhandbuch* emphasized that the innovative wallpaper-printing machines invented by machine builder *Carl Schoening AG* (IPO in 1903) were patented in all important industrialized countries.[3] In 1911, it gave detailed information on the number and life-spans of the national and international patents held by *Carl Lindström AG* (IPO in 1910), which was engaged in precision engineering.[4] In the *Deutsche Bank* historical archives, we found direct evidence of our assumption that firms used information on their patenting activities as a signal to attract financial investors. Promoting the issuance of its corporate bond in the newspaper *Frankfurter Zeitung* in October 1911, for example, the corporation *T. H. Goldschmidt Aktiengesellschaft* highlighted that it had bought several foreign companies in order to exploit its foreign patents on aluminum production.[5] *Stahlwerke Rich. Lindenberg AG* stressed, in a 1910 prospectus, that it possessed exclusive

[1] For a complete overview of the German banking system, see Guinnane (2002).

[2] Burhop (2006) also finds a positive relationship between the savings banks' financial depth and Germany's real capital stock for the period 1883 to 1913. This finding implies that the savings banks' role in financing Germany's small and medium-sized industry was more important than hitherto assumed. See also Proettel (2013).

[3] See Salinger Börsenhandbuch (1904, p. 1303 f).

[4] See Salinger Börsenhandbuch (1911, p. 1501 f).

[5] See Historical Archives of the Deutsche Bank (HADB, SG 31-10).

German and Luxembourgian licenses for the fused-salt electrolysis of aluminum invented by the Frenchman Paul Héroult in 1886 (HADB SG 31-21). The machine builder *Maschinenfabrik Bruchsal*, to give a final example, pointed out in 1909 that one of its main businesses was the acquisition and use of patents. All these firms are contained in our sample.

In order to get a more systematic impression of the role of patents as signals at the Berlin stock exchange, we first scanned all the written material the *Salinger Börsenhandbuch* provided about each of the 474 IPOs that took place in the German capital between 1892 and 1913 for explicit information about patents. We found that about 50 percent of the 139 firms which had at least one patent before going public promoted their IPO with a reference to their intellectual property rights. The probability that a firm used this kind of advertisement increased with the number of patents it had already received. Whereas only 25 percent of the firms with only one patent made this information public, three-quarters of the firms which patented more than ten innovations mentioned their patents at the time of their IPO. In a second step, we collected a random sample of historical listing prospectuses advertising IPOs and SEOs (seasoned equity offerings) in the *Berliner Börsenzeitung*. Selecting all listing prospectuses that were published on odd-numbered Mondays of the years 1896, 1899, 1902, 1905, and 1908, we found that, in 15 percent of the 80 listing prospectuses in our sample, patents were mentioned to signal the quality of the firm.[6] However, such signals could be misleading with respect to the firms' future innovativeness (and therefore future profitability). A closer look at the data reveals that the innovative firms' patent history differs widely. We distinguish three types of innovative firms. *Permanently innovative firms* received patents before and after the IPO. *Innovative startups* had none or just a few patents before IPO, but many afterward, suggesting that they indeed needed investor capital to finance their R&D activities. In contrast, the third group of innovative firms lost their traditional innovativeness after their IPO. Following Thomas Mann's famous novel in which he described the gradual decline of a family-owned company in Lübeck, we call them the *Buddenbrooks* of our sample. In the case of these *Buddenbrooks*, the inflow of equity capital apparently diminished incentives to innovate (for similar findings, see Bernstein 2015).

In the remaining paper, we will first present evidence suggesting that the Berlin stock exchange was predominantly used by innovative firms as a source of financing. In a second step, we shift our attention to the investors' decision making: did investors prefer innovative firms to non-innovative ones and, if this was true, could investors distinguish firms with future innovativeness from *Buddenbrooks* that also signaled their past patent activities? To evaluate the market's efficiency, we will finally take a look at the long-run performance of the IPO stock.[7]

[6] For more details, see Tables A5 and A6 in the online Appendix.

[7] Note that we will not model a firm's decision to go public (see Pástor, Taylor, and Veronesi 2009). In Imperial Germany, an entrepreneur could choose between various organizational forms such as commercial partnership, limited partnership, private limited liability company, and (listed or nonlisted) corporation (Guinnane et al. 2007). It is still a subject of ongoing research to identify all the firm characteristics that influenced this choice. Among these factors might be firm size, family ties among owners, tax considerations (Guinnane and Martínez-Rodríguez 2015), and the need to finance innovation.

I. Data and Descriptive Statistics

In the following, we analyze the performance of all 474 IPOs[8] that took place on the Berlin stock exchange between 1892 and 1913, the last year of peace before the outbreak of the First World War. The starting year of our observation period is determined by the availability of a daily stock index, which is needed to evaluate the performance of a particular firm's shares in comparison to the rest of the market. We rely on the market benchmark Gelman and Burhop (2008) calculated for the years from 1892 to 1913. Information on the IPOs of the period 1897–1913 was taken from the *Vierteljahrshefte zur Statistik des Deutschen Reichs* (see also Lehmann 2014). This record includes the date of issue, share capital at IPO, firm name, location of headquarters, and name of the lead underwriting bank. Data on the IPOs that took place between 1892 and 1896 were collected by Burhop (2011) using various contemporary sources. Firm-specific variables such as the age of a newly listed corporation and its profit in relation to the book value in the year before the IPO were taken from the *Salinger Börsenhandbuch* and from the *Handbuch der deutschen Aktiengesellschaften* (Handbook of German joint-stock companies). Prices and dividends were taken from the *Berliner Börsenzeitung*.

Our identification strategy is based on the assumption that contemporary investors used a firm's patent history to assess its future innovativeness and hence its future profitability. Whereas some industries try to appropriate the return of their innovations with the help of patenting activities, others prefer to keep them secret instead. As Streb (2016, p. 450) discusses, given these differences in the industries' patenting activities, it could be misleading to interpret a firm's comparatively low number of patents automatically as a sign of a below-average level of innovation. To assess the magnitude of this measurement problem in a historical context, Moser (2012) uses an alternative source to identify innovations. She looks at the number of British and American exhibits presented at world fairs between 1851 and 1915. At the Crystal Palace exhibition in London in 1851, for example, approximately 89 percent of British exhibits and 85 percent of American ones were without patents. In addition, Moser identifies considerable differences in the industries' propensity to patent. In 1851, the industry-specific patenting rates of British exhibits ranged from 30 percent in manufacturing machinery and 25 percent in engines to a mere 5 percent in mining and metallurgy. Moser concludes that patenting rates were especially low in those industries where innovations were difficult to imitate. In the mid-nineteenth century, this argument also applied to chemicals, because modern methods of chemical analysis that allowed chemical products to be "reengineered" had not yet been developed. However, Streb, Baten, and Yin (2006) show that things had changed by the end of the nineteenth century, when the propensity to patent was especially strong in the German chemical industry. The same was true for other "high-tech" industries of this period, such as electrical engineering or machine building. Since German firms of these "new" industries also dominate our sample of IPOs (see Table 4), we assume that our statistical results are not invalidated by this type of potential measurement error.

[8] We define German IPOs as firms going public for the first time in Berlin. This excludes foreign firms, German firms that were formerly listed abroad, and those listed on another German stock exchange.

Another problem is that pure patent counts allocate the same weight to every patent, regardless of the economic value for the patentee. In (historical) research, however, it is possible to deal with this problem. Streb (2016, p. 451 f.) explains that in some historical patent systems like those of Germany or the United Kingdom, where patent holders had to renew their patents regularly by paying a renewal fee, valuable patents can be identified by their individual life-span (Schankerman and Pakes 1986; Sullivan 1994). Legislators introduced patent renewal fees in the hope that many patent holders who were not able to exploit their patents profitably would give them up long before the maximum possible patent duration had elapsed. If this mechanism worked as intended, a long life-span of a patent can be seen as a reliable indicator of its comparatively high private economic value. Streb, Baten, and Yin (2006) interpreted those German patents that survived at least ten years as the valuable patents within the German Empire.[9] Their patent dataset comprises about 40,000 long-lived German patents that were granted to firm and private inventors between 1877 and the end of the First World War.[10] From this dataset, we draw information on the valuable patents of those firms that went public in Berlin between 1892 and 1913.

However, information on a particular patent's life-span is ex post knowledge. Contemporary investors could not know how long a patent issued prior to an IPO was finally held, but probably had to assess a firm's innovativeness on the pure patent count. That is why we decided against using only available information on German firms' long-lived patents and instead collected new data on all patents granted. The *Verzeichnis der im Vorjahre erteilten Patente*, which was published annually by the Imperial patent office, contains an alphabetical list of all innovative firms and private inventors with information on the respective number of patents they had received in the preceding year. With this information on the name and location of the firms that went public between 1892 and 1913, we can identify all patents that were assigned to these firms both before and after their respective IPO.[11] Table 1 provides an overview of the IPOs' patenting activities.

Of the 474 firms going public, 40.7 percent received patents either before the IPO or within the first five years after going public. On the actual day of the IPO, 139 firms (29.3 percent) held at least one patent, and 109 firms (23.0 percent) got a patent in the first five years after going public. As might be expected, the number of valuable patents was much lower (in sum total we observe 8,671 patents and 1,403 valuable patents), and the valuable patents were concentrated on a smaller number of firms. Given that the distribution of valuable patents across inventors was highly skewed in Imperial Germany, the share of firms with valuable patents in all IPOs (19.2 percent) is still surprisingly high. Degner (2009), for example, shows that, from 1877 to 1900, two-thirds, and, from 1901 to 1932, between 40 and 55 percent of all valuable German patents granted to domestic firms were held by only the

[9] In the German patent system, the cancellation rate was high. About 70 percent of all German patents that were granted between 1891 and 1907 were canceled after just five years. About 10 percent of all patents were still in force after ten years, and only about 5 percent reached the maximum age of 15. See Streb, Baten, and Yin (2006, p. 352).

[10] See also Burhop and Lübbers (2010); Richter and Streb (2011); Streb, Wallusch, and Yin (2007).

[11] Note that our patent data are truncated on both sides of the time bar. The introduction of the first German patent law in 1877 marks the first year in which it was possible to get a German patent. Since the Imperial patent office did not reveal the name of patent holders during wartime, the beginning of the First World War terminates the end of the period for which firm-specific patent data are available.

Table 1—Patenting Activities of IPOs at the Berlin Stock Exchange between 1892 and 1913

	Total	Percentage of all 474 IPOs
All firms with patents	193	40.7
Firms with patents before IPO	139	29.3
Firms with patents within 5 years after IPO	109	23.0
Firms with patents before and within 5 years after IPO	77	16.2
All firms with valuable patents	91	19.2
Firms with valuable patents before IPO	44	9.3
Firms with valuable patents within 5 years after IPO	45	9.5
Firms with valuable patents before and within 5 years after IPO	25	5.3

30 most innovative firms, whereas about 266,000 firms with more than five workers existed in Germany in 1930.

II. The Correlation between Going Public and Patenting Activities

As all firms in our sample sooner or later got listed on the Berlin stock exchange, the number of newly granted patents per listed firm grew rather mechanically over time.[12] To answer the question as to whether going public changed the firms' patenting intensity, it is therefore necessary to eliminate this time trend. We use an event-study specification and code separate dummies for the five years before and the five years after an IPO took place.[13] Each dummy takes the value 1 only in a single calendar year. When a particular firm's IPO took place in 1900, for example, the dummy *IPO-2years* will be set to 1 in year 1898 and to 0 in all other years. The omitted category is the year of the IPO. This approach allows us to compare the pre- and post-IPO patenting activities of firms that went public in different years. We consider both all newly granted patents and the subgroup of newly granted patents that turned out to be valuable. Table 2 shows significant negative beta coefficients in some of the years before the IPO, and significant positive ones in some years after the IPO. Figure 1 and Figure 2 plot the respective beta coefficients for the fixed effects (FE) model of the full sample of firms. In sharp contrast to Bernstein (2015), who identified a decrease in patent quality after IPO on the NASDAQ in the late twentieth century, the number of newly granted valuable patents in our case followed a similarly positive trend as the number of all patents.

These findings suggest that getting listed on the Berlin stock exchange helped German firms to overcome liquidity constraints that had previously limited their innovative activities. However, we do not establish a causal link between going public and the firms' innovative activities, for two reasons. First, we lack precise information about how much of the new capital raised by going public was actually invested, by the firms of our sample, in R&D or in the establishment of the

[12] See Figure A1 in the online Appendix.

[13] For a 20-year horizon, see Table A3 and Figure A3 in the online Appendix. For a similar approach analyzing the impact of railways on growth, see also Hornung (2015).

Table 2—Patenting Activities 5 Years before and 5 Years after the IPO Event

	All newly granted patents			All newly granted valuable patents		
Sample	All IPOs 1892–1913	All IPOs 1892–1913	Just IPOs with patents	All IPOs 1892–1913	All IPOs 1892–1913	Just IPOs with patents
Model:	Pooled	FE	FE	Pooled	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)
IPO − 5 years	−0.319	−0.321	−0.811	−0.0127	−0.0531	−0.134
	(0.156)	(0.154)	(0.376)	(0.0343)	(0.0521)	(0.125)
IPO − 4 years	−0.384	−0.416	−1.058	−0.0738	−0.105	−0.268
	(0.174)	(0.184)	(0.476)	(0.0351)	(0.0506)	(0.125)
IPO − 3 years	−0.399	−0.432	−1.110	−0.0654	−0.0923	−0.243
	(0.173)	(0.179)	(0.482)	(0.0357)	(0.0462)	(0.119)
IPO − 2 years	−0.327	−0.316	−0.774	−0.0485	−0.0719	−0.192
	(0.152)	(0.145)	(0.371)	(0.0311)	(0.0372)	(0.0992)
IPO − 1 year	0.0591	0.0668	0.176	−0.0295	−0.0389	−0.106
	(0.202)	(0.192)	(0.464)	(0.0257)	(0.0258)	(0.0642)
IPO + 1 year	0.143	0.151	0.393	0.00422	0.00208	−0.00644
	(0.139)	(0.136)	(0.343)	(0.0287)	(0.0279)	(0.0739)
IPO + 2 years	0.357	0.334	0.799	−0.00171	0.00581	−0.0108
	(0.318)	(0.301)	(0.700)	(0.0368)	(0.0364)	(0.0913)
IPO + 3 years	0.440	0.360	0.877	0.0387	0.0544	0.117
	(0.287)	(0.225)	(0.545)	(0.0369)	(0.0389)	(0.0902)
IPO + 4 years	0.558	0.423	1.089	0.0732	0.0766	0.184
	(0.320)	(0.192)	(0.482)	(0.0422)	(0.0405)	(0.0941)
IPO + 5 years	0.318	0.176	0.457	0.0256	0.0515	0.127
	(0.230)	(0.105)	(0.271)	(0.0426)	(0.0308)	(0.0780)
Constant	0.774	0.898	2.156	0.110	0.204	0.496
	(0.238)	(0.198)	(0.455)	(0.0407)	(0.0981)	(0.232)
Year dummies	No	Yes	Yes	No	Yes	Yes
Firm fixed effects	No	Yes	Yes	No	Yes	Yes
Observations	5,039	5,039	2,035	5,039	5,039	2,035
R^2	0.002	0.012	0.030	0.002	0.013	0.033
Number of firms	474	474	193	474	474	193

Notes: Reported standard errors are clustered by firm. Clustered standard errors in parentheses.

additional production capacities that were needed to manufacture innovative products. Some indirect evidence is provided by Franks, Mayer, and Wagner (2006, p. 560). They show that, around the year 1900, German firms used about 90 percent of their new equity capital for internal investment (which would include investment in new technologies), whereas firms from the United Kingdom primarily invested in external acquisitions of factories. Second, and more importantly, we cannot answer the question of how many patents innovative firms would have achieved without going public. To analyze this counterfactual scenario with the help of an elaborate difference-in-differences approach, we would need to construct a control group of firms which only differ from historical IPOs with regard to their decision to remain private. A particular problem is that there exists no clearly defined starting year of the treatment period. Firms could go public in any year of our observation period, and it is not possible to identify the hypothetical year in which the probability that a never-listed "control firm" would have gone public was the highest.

In a less demanding exercise, we compare the patenting activities of listed and nonlisted innovative firms on the basis of a sample that has been provided by

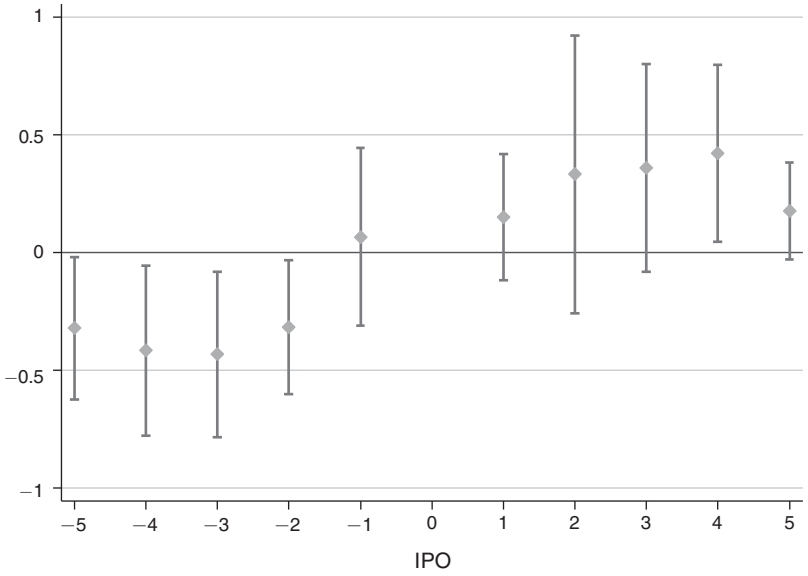

Figure 1. Newly Granted Patents around the IPO Event

Note: Beta coefficients and 95 percent confidence intervals of year dummies, corresponds to Table 2, regression (2).

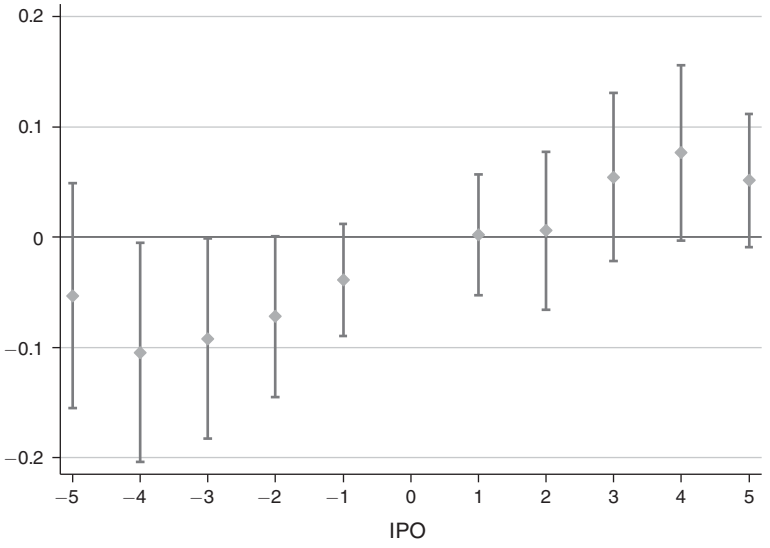

Figure 2. Newly Granted Valuable Patents around the IPO Event

Note: Beta coefficients and 95 percent confidence intervals of year dummies, corresponds to Table 2, regression (5).

Degner (2009). He selected all German firms which were among the 100 most innovative German firms (measured by valuable patents) in at least one year of the period from 1877 to 1932. We dropped all firms which had no valuable patent in our shorter observation period, firms which went public on a regional stock exchange, or first on a regional stock exchange and later in Berlin, and firms which went public

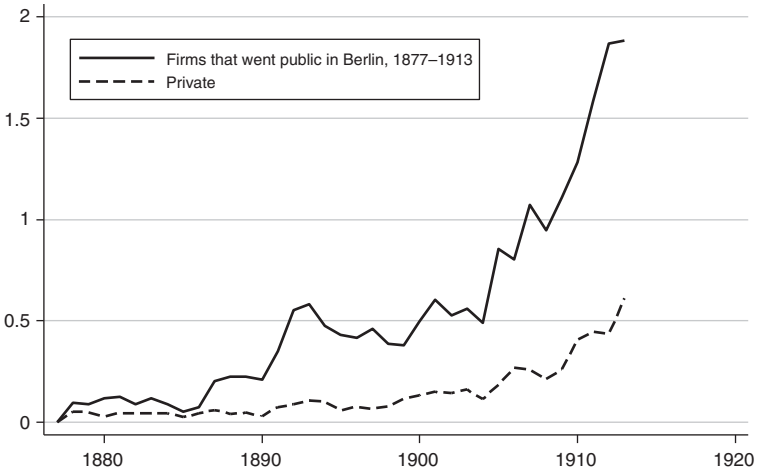

FIGURE 3. NEWLY GRANTED VALUABLE PATENTS PER FIRM: MOST INNOVATIVE FIRMS

either before 1877 or later than 1913. This reduces Degner's sample from 1,418 to 911 firms. Of the latter, 137 firms went public in Berlin between 1877 and 1913, whereas 774 stayed private.[14]

Figure 3 shows that, in the early 1880s, the patenting activities of both groups of firms did not differ much. In the later 1880s, however, the patenting activities of listed and nonlisted firms began to diverge. On the eve of the First World War, listed firms achieved on average about three times as many new valuable patents as nonlisted ones. Based on this sample, we estimate a panel fixed effect model, which is reported in column 3 of Table 3. Going public significantly increased the number of valuable patents an innovative firm could achieve (see the dummy variable *Going public*), but this effect became smaller with growing temporal distance to the year of the IPO (interaction term *Going public* $\times$ *year*). The regression also confirms that the patenting activities of listed and nonlisted firms generally diverged over time (*Firms that go public* $\times$ *year*). Taken together, these observations support our hypothesis that going public helped to finance innovation activities measured by patents. Columns 1 and 2 show that similar effects took place in our smaller sample of 474 firms which went public between 1892 and 1913.

Finally, Table 4 reveals that the distribution of patents varied widely across sectors. Most firms with (valuable) patents can be found in key innovative industries of the Second Industrial Revolution, such as metal working, machines, and chemicals. In addition, we observe very few "very innovative" firms. Only 47 firms (10 percent), for instance, had received more than 10 patents, and only 9 firms (2 percent) more than 10 valuable patents before the day of the IPO (see online Appendix, Table A7).

We have established the fact that a disproportionally high share of innovative firms used the Berlin stock exchange as a source of external capital. To assess

[14] For descriptive statistics, see Table A4 in the online Appendix.

Table 3—Patenting Activities 1877–1913: IPOs versus Private Firms

Sample:	All IPOs 1892–1913		Most innovative firms, IPOs versus private
Dependent variable:	Newly granted patents (1)	Newly granted valuable patents (2)	Newly granted valuable patents (3)
Going public (= 1 if year > = year of IPO)	0.504	0.0994	0.372
	(0.254)	(0.0584)	(0.157)
Going public × year (year of IPO = 0)	−0.0162	−0.0104	−0.0365
	(0.0139)	(0.00589)	(0.0211)
Firms that go public × year (1877 = 0)			0.0213
			(0.00877)
Year (1877 = 0)	0.0201	0.00520	0.0106
	(0.00453)	(0.00146)	(0.00215)
Constant	−0.0383	−0.0385	−0.0678
	(0.151)	(0.0381)	(0.0436)
Firm fixed effects	Yes	Yes	Yes
Observations	17,538	17,538	33,707
R^2	0.011	0.010	0.029
Number of firms	474	474	911

Notes: Reported standard errors are clustered by firm. Clustered standard errors in parentheses.

Table 4—IPOs of Innovative Firms at the Berlin Stock Market by Sector between 1892 and 1913

Sector:	Machine and metal working	Chemicals	Textiles	Mining	Others	Total
Firms with patents (A)	115	15	10	14	29	193
Percent of IPOs in this sector	79.3	66.2	27.7	32.5	20.7	40.7
Patents before IPO (B)	2,226	71	69	43	365	2,773
Patents before IPO per firms if patents > 0 (B/A)	19.4	4.7	6.9	3.1	12.6	14.4
Patents within 5 years after IPO	1,987	61	23	16	759	2,846
Firms with valuable patents (C)	62	7	6	5	11	91
Percent of IPOs in this sector	42.7	30.4	10.6	11.65	5.1	19.2
Valuable patents before IPO (D)	290	13	5	3	45	356
Valuable patents before IPO per firms if valuable patents > 0 (D/C)	4.7	1.9	0.8	0.6	4.1	3.9
Valuable patents within 5 years after IPO	266	19	1	4	47	337

whether investors preferred those firms to non-innovative firms, we will now take a closer look at the short-run and long-run performance of the IPOs in our sample.

III. Short-Term and Long-Term Performance

The simplest and most often applied measure for short-run performance on the stock market is the initial return, which is the difference between the first trading price and the offering price at which the underwriting bank presents the IPO's shares to potential investors. A development typically observed in modern markets is that the price of a new share shoots up on the first trading day, which means that the initial return is systematically positive. This short-term price increase indicates

a strong demand for the newly traded shares, implying that they could have been priced higher at issue. If the issuing price had been higher, the company would have raised more capital. When an issue is underpriced in this way, it is assumed that the company (or the underwriting bank) has left money on the table.[15]

From a theoretical perspective, it is not clear whether we should expect initial returns to be higher or lower when an innovative firm goes public. If investors shrink back from the high degree of uncertainty that comes with extensive R&D activities, banks might consider choosing an especially low issuing price in order to attract sufficient demand for the issue. Analyzing about 2,700 IPOs in the US market between 1980 and 1995, Guo, Lev, and Shi (2006) find that R&D expenditures are in fact positively correlated with underpricing. This result, however, might not imply that investors dislike innovative firms per se, but might instead mirror the fact that R&D expenditures are in general not a reliable predictor of the output of R&D processes. From the viewpoint of investors on the stock market, R&D expenditures are not a signal of a firm's long-term profitability, but are primarily a significant short-term cost item. Patents might be different because they document only those R&D activities that actually led to technological breakthroughs. Whereas R&D expenditures create risk, patents reduce risk and promise future economic profits. That is why investors might prefer to buy shares of firms with many patents. If the bank anticipates this preference, it can charge a comparatively high issuing price and initial returns will be relatively low. Bessler and Bittelmeyer (2008) confirm this hypothesis for modern markets.[16]

Previous quantitative studies on IPOs in a historical setting failed to identify the significant determinants of underpricing. In contrast to what theory suggests, underpricing seemed to be white noise that was largely unaffected by firm-specific, bank-specific, or market-specific factors (Burhop 2011; Lehmann 2014). However, patents which might have either increased or reduced information asymmetry with regard to an IPO's future performance have not yet been used as an explanatory variable.[17] We have already established that the patent histories of innovative firms differ widely and therefore distinguished *permanently innovative firms*, *innovative startups*, and *Buddenbrooks*. To operationalize this differentiation, we introduce three dummy variables. The dummy *innovative startup* is set to one if the respective firm received at least ten times more patents in the first five years after its IPO than during its full existence before its IPO. Conversely, the dummy *Buddenbrooks* is set to 1 if a firm's number of patents before its IPO was at least ten times as high as in

[15] The phenomenon of underpricing was first documented by Stoll and Curley (1970); Logue (1973); Reilly (1973); and Ibbotson (1975). Empirical studies show that underpricing also existed in historical stock markets, but to a much lower extent than in modern markets, where underpricing averaged about 15 percent in the United States (Ritter 1991); Germany (Ljungqvist 1997); and France (Biais, Bossaerts, and Rochet 2002). By contrast, Weigt (2005); Burhop (2011); and Lehmann (2014) observe only about five percent underpricing on the Berlin stock exchange between the 1880s and the First World War. Chambers and Dimson (2009) find around ten percent in the interwar period on the London Stock Exchange. For a review of theories on the reasons for IPO underpricing, see Ritter and Welch (2002).

[16] Interestingly enough, Müller and Reize (2010) show that holding patents increased the probability of getting a bank loan for small and medium-sized German firms in the 2000s.

[17] We also found that a large number of patents before IPO seemed to have a negative effect on initial returns, whereas a large amount of valuable patents had a positive impact on the first trading price. See Tables A9 in the online Appendix. This result suggests that patents signal lower risk and higher future profitability.

the first five years following.[18] All other innovative firms, the patents of which were more equally distributed over time, are defined as *permanently innovative firms*. The group of non-innovative firms[19] without any patents serves as a benchmark.

In addition, we control for other factors which have been identified as influential variables in modern stock markets. A high reputation of the lead underwriting bank might have dispersed investors' doubts about the quality of an IPO, which implies that IPOs which were issued by those banks should have lower initial returns than others (see, for instance, Chemmanur and Fulghieri 1994; Carter, Dark, and Singh 1998). To take care of this reputation effect, we introduce a dummy variable (*Big Four banks*) that is set equal to 1 if the lead underwriter was *Deutsche Bank*, *Dresdner Bank*, *Discontogesellschaft*, or *Darmstädter Bank* (Lehmann 2014). The intuition behind including both *size of the issue* and *age of firm* is that investors probably had more information about large and already well-established companies than about small and young ones. Due to this additional information, the problem of asymmetric information among different groups of investors might have become less important, and initial returns therefore declined. *Distance*, which equals the distance in kilometers between the headquarters and Berlin, also controls for information asymmetries. Finally, we control for the average stock market return of the previous year (*past market returns*) to test Burhop's hypothesis that contemporary investors' expectations were influenced by the general economic and political climate, as well as the liquidity of the financial market (Burhop 2011). Furthermore, we include sector and year effects. Overall, we categorized the IPOs into six different sectors: banks, chemicals, metalworking, mining, textiles, and others. Others includes sectors for which we observe just a few firms, such as food processing, transport, and construction.

Based on the daily stock market index provided by Gelman and Burhop (2008), we compute the dependent variable market-adjusted *initial returns* as follows:

$$IR = \left(\frac{p_{first} - p_{offering}}{p_{offering}}\right) - \left(\frac{A_{first} - A_{offering-1}}{\mathrm{A}_{offering-1}}\right),$$

where p_{first} is the price[20] on the first trading day, $p_{offering}$ the offering price fixed by the underwriting bank, A_{first} equals the actual stock market index on the first trading day of the IPO, and $A_{offering-1}$ is the stock market index the day before the first trading day. Our data demands reduce the sample from 474 to 292 observations.[21] However, we do not concentrate solely on underpricing (*initial returns*), but also

[18] Our results are robust to changes in the demarcation between innovative startups, *Buddenbrooks*, and permanently innovative firms (see Tables A13 and A14 in the online Appendix). Furthermore, one might argue that the fact that we do not observe firm-specific patenting activities during the First World War may lead to a wrong assignment of firm types for firms that went public after 1909. Tables A15 and A16 in the online Appendix provide evidence that the results remain unaffected by this issue.

[19] In the context of this research, non-innovative only means that firms could not signal their innovativeness to potential investors with the help of easily observable patent data. It is conceivable that the group of non-innovative firms might have had non-patented innovations.

[20] In the following analysis, we measure the first trading price in percentage of the nominal share value.

[21] Instead of publicly offering all shares before the first day of trading, banks could start issue by privately placing shares. We assume that all IPOs for which we cannot observe the offering price were preceded by private placement. See Moral (1914, p. 49).

evaluate the explanatory variables' influence on the *first trading price*, for which we have 430 observations.[22] The regressions are estimated with ordinary least squares and standard errors clustered by sector. Table 5 provides the results.[23]

The most important result of these regressions is that *innovative startups* are characterized by both comparatively low initial returns and a comparatively high first trading price. This observation implies that the contemporary investors' information set was not limited to the IPOs' patent history. They obviously had access to additional information that allowed them correctly to expect the future innovativeness of IPOs that had not yet been proven by patenting activities. Since we control for the *size of the issue*, *age of the firm*, and its actual *return on capital*, this additional information is not based on easily observable data on the firms' past economic performance. Reputation effects that spilled over from the lead underwriting bank are also covered. Even though the respective coefficients are not significant, *Buddenbrooks* and *permanently innovative firms* also performed better than the control group of non-innovative firms.

We have already seen that not every firm which had received patents also informed investors about them at the time of the IPO in easily accessible documents such as listing prospectuses. It is therefore conceivable that investors considered only those patents that were actually used as public signals. To test for this possibility, we introduce the dummy *signal* which takes the value 1 if the *Salinger Börsenhandbuch* provided information about the patents that a firm going public held. Alternatively, we distinguish between firms which only mentioned their patents (dummy *patents mentioned*) and firms which emphasized the role of their patents for future market success (dummy *patents advertised*). Table 6 shows that using patents as a signal neither decreased nor increased *initial returns*. Mentioning patents before the IPO, however, led to an increase in the *first trading price*. To sum up, being innovative did not scare off investors at the Berlin stock exchange. Rather, the opposite was true: our results suggest that the stock exchange channeled funds from non-innovative firms to innovative ones.

Tables 5 and 6 provide some other surprising findings. *Initial returns* decreased with geographical *distance* to Berlin. This result implies that distant firms were subject to some other selection process than firms in the geographical neighborhood of the Berlin stock exchange. It is conceivable that underwriting banks only took the best known and most successful firms from other parts of Germany to Berlin (instead of placing them on a regional stock exchange), whereas firms near Berlin did not need to fulfill these preconditions.[24] The positive relationship between *Big Four banks* and *the first trading price* supports the assumption that investors inferred from the underwriting banks' reputation that the future profits of the respective firms

[22] Tables A1 in the online Appendix provides overviews and descriptive statistics of all variables and subsamples.

[23] Overall, the regressions explain about 12 to 20 percent of the overall variation of the dependent variables. This is relatively high in comparison to other empirical studies in which the R^2 hardly exceeds 10 percent (see Burhop 2011; Lehmann 2014).

[24] Though firms had to have at least 1 Million Marks of share capital in order to get access to the Berlin stock exchange, the stock exchange admission board could decide to list smaller firms if they were considered of particular importance for the regional economy around Berlin (see Burhop and Lehmann-Hasemeyer 2014).

Table 5—IPOs' Short-Run Performance by Different Firm Types

	Initial return		First trading price in percent of nominal share value	
	(1)	(2)	(3)	(4)
Innovative startups	−2.349	−2.166	16.34	19.55
	(0.779)	(0.662)	(11.60)	(7.255)
Buddenbrooks	−0.665	−0.732	13.79	10.28
	(1.029)	(0.710)	(5.156)	(6.236)
Permanently innovative	−1.534	−1.277	20.95	22.25
	(0.758)	(0.688)	(6.623)	(11.09)
Past market return		−11.29		−269.1
		(58.14)		(75.49)
Size of the issue		−0.0243		−0.217
		(0.0417)		(0.467)
Age of the firm		0.0581		0.615
		(0.0564)		(0.439)
Distance		−0.121		0.986
		(0.0442)		(0.921)
Big Four banks		0.295		16.89
		(0.453)		(4.381)
Constant	3.611	4.360	141.9	130.5
	(0.141)	(3.191)	(0.624)	(2.742)
Sector dummies	Yes	Yes	Yes	Yes
Year of IPO dummies	No	Yes	No	Yes
Observations	292	292	430	430
R^2	0.042	0.129	0.090	0.206

Notes: Reported standard errors are clustered by sector (six clusters). Clustered standard errors in parentheses.

would be comparatively large. In Table 5, *past market returns* had a negative impact on first trading prices.[25]

To evaluate the efficiency of the Berlin stock exchange, we finally look at the IPOs' long-term performance. Loughran and Ritter (1995) show that, in modern markets, IPO stocks performed significantly worse than shares of more seasoned firms in the first five years after going public. In contrast, Guo, Lev, and Shi (2006) observe that long-term underperformance of IPOs only occurred in those cases when non-innovative firms went public on the US stock exchange between 1980 and 1995. Both results suggest that investors were often too optimistic about the future prospects of IPOs. If investors had anticipated future returns correctly on the first trading day, the long-run performance of newly listed corporations should not have significantly deviated from the general stock market development. In sharp contrast to these results, none of our four types of IPOs performed worse than the stock market index,[26] which suggests that contemporary investors did not overestimate the IPOs' future gains on the first trading day. Differences between the four firm types with respect to mean and coefficient of variation of *stock prices*, *annual returns*, and *annual excess returns* in the five years after the IPO are generally not significant

[25] The results are robust to changes in sample size. Table A12 in the online Appendix provides the regression results based on the reduced sample of 292 observations.

[26] See Table A20 in the online Appendix.

TABLE 6—IPOs' SHORT-RUN PERFORMANCE WITH RESPECT TO SIGNALING PATENTING ACTIVITIES

	Initial return		First trading price in percent of nominal share value	
	(1)	(2)	(4)	(5)
Signal	1.196		19.80	
	(1.006)		(8.574)	
Patents mentioned		0.999		14.19
		(0.835)		(4.745)
Patents advertised		1.609		29.15
		(1.596)		(19.62)
Size of the issue	−0.0317	−0.0318	−0.268	−0.253
	(0.0435)	(0.0433)	(0.443)	(0.429)
Age of the firm	0.0612	0.0591	0.656	0.656
	(0.0597)	(0.0589)	(0.481)	(0.477)
Distance	−0.092	−0.089	0.999	1.029
	(0.0209)	(0.0182)	(0.794)	(0.824)
Big Four banks	0.299	0.286	17.07	16.57
	(0.480)	(0.453)	(3.884)	(3.725)
Constant	3.520	3.535	120.4	120.4
	(0.480)	(0.420)	(1.526)	(1.502)
Sector dummies	Yes	Yes	Yes	Yes
Year of IPO dummies	Yes	Yes	Yes	Yes
Observations	292	292	430	430
R^2	0.123	0.124	0.205	0.209

Notes: Reported standard errors are clustered by sector (six clusters). Clustered standard errors in parentheses.

either.[27] Only the *permanently innovative* firms' higher long-term mean of stock prices comes along with a significantly higher risk that is a higher coefficient of variation.[28] However, most of the differences in future profitability and risk across the four types of IPOs were already covered by the differences in the first trading price.

IV. Conclusion

In the decades before the First World War, Germany changed from a comparatively backward country to a global industrial leader, especially excelling in new and innovative industries such as chemicals, electrical engineering, or machine building. Until now, however, the question of how German firms were able to finance their very risky innovation activities has remained widely unanswered. This paper shows that many innovative companies used the Berlin stock exchange as a source of financing. Even more surprising is the fact that innovators were not penalized by relatively high initial returns or low first trading prices. On the contrary, innovative startups that needed equity capital to run their risky R&D projects realized comparatively high offering prices and, in the longer run, they performed no worse than more seasoned

[27] The latter performance measures include regular dividends and *Stückzinsen*, which were a fixed yearly payment of four percent of the face value that was paid at the start of the trading year. To compute the *annual excess returns*, the return of the stock market index is subtracted from the IPO's *annual returns*. See, for instance, Barber and Lyon (1997).

[28] See Table A17 in the online Appendix.

corporations. Our findings suggest that, in the decades before the First World War, the Berlin stock exchange worked as an efficient market for new technology that channeled equity funds from non-innovative firms to innovative ones.

It might therefore be misleading to interpret nineteenth-century Germany's financial sector as the textbook example of a bank-based financial system. It is true that Germany had a well-developed banking sector with large universal banks, many small savings banks, and credit cooperatives. But the German economy could also rely on the large and efficient Berlin stock market with a market capitalization above the world average (Rajan and Zingales 2003) and, in terms of efficiency, on a par with London (Gelman and Burhop 2008; Burhop, Chambers, and Cheffins 2011). To conclude, Germany's industrialization and innovation depended much more than previously assumed on the provision of equity capital.

REFERENCES

Allen, Franklin, and Douglas Gale. 2000. *Comparing Financial Systems.* Cambridge, MA: MIT Press.

Barber, Brad M., and John D. Lyon. 1997. "Detecting Long-Run Abnormal Stock Returns: The Empirical Power and Specification of Test Statistics." *Journal of Financial Economics* 43 (3): 341–72.

Bernstein, Shai. 2015. "Does Going Public Affect Innovation?" *Journal of Finance* 70 (4): 1365–403.

Bessler, Wolfgang, and Claudia Bittelmeyer. 2008. "Patents and the Performance of Technology Firms: Evidence from Initial Public Offerings in Germany." *Financial Markets and Portfolio Management* 22 (4): 323–56.

Biais, Bruno, Peter Bossaerts, and Jean-Charles Rochet. 2002. "An Optimal IPO Mechanism." *Review of Economic Studies* 69 (1): 117–46.

Black, Bernard S., and Ronald J. Gilson. 1998. "Venture Capital and the Structure of Capital Markets: Banks versus Stock Markets." *Journal of Financial Economics* 47 (3): 243–77.

Burhop, Carsten. 2006. "Did Banks Cause the German Industrialization?" *Explorations in Economic History* 43 (1): 39–63.

Burhop, Carsten. 2011. "The Underpricing of Initial Public Offerings at the Berlin Stock Exchange, 1870–96." *German Economic Review* 12 (1): 11–32.

Burhop, Carsten, David Chambers, and Brian Cheffins. 2011. "Is Regulation Essential to Stock Market Development? Going Public in London and Berlin, 1900–1913." Max Planck Institute for Research on Collective Goods Bonn Working Paper 2011/15.

Burhop, Carsten, and Sibylle Lehmann-Hasemeyer. 2014. "The Geography of Stock Exchanges in Imperial Germany." Forschungszentrum Innovation und Dienstleistung Discussion Paper 89-2014.

Burhop, Carsten, and Thorsten Lübbers. 2010. "Incentives and Innovation? R&D Management in Germany's Chemical and Electrical Engineering Industries around 1900." *Explorations in Economic History* 47 (1): 100–11.

Calomiris, Charles W. 1995. "The Costs of Rejecting Universal Banking: American Finance in the German Mirror, 1870–1914." In *Coordination and Information: Historical Perspectives on the Organization of Enterprise*, edited by Naomi R. Lamoreaux and Daniel M. G. Raff, 257–315. Chicago: University of Chicago Press.

Carter, Richard B., Frederick H. Dark, and Ajai K. Singh. 1998. "Underwriter Reputation, Initial Returns, and the Long-Run Performance of IPO Stocks." *Journal of Finance* 53 (1): 285–311.

Chambers, David, and Elroy Dimson. 2009. "IPO Underpricing over the Very Long Run." *Journal of Finance* 64 (3): 1407–43.

Chemmanur, Thomas J., and Paolo Fulghieri. 1994. "Investment Bank Reputation, Information Production, and Financial Intermediation." *Journal of Finance* 49 (1): 57–79.

Degner, Harald. 2009. "Schumpeterian German Firms before and after World War I: The Innovative Few and the Non-Innovative Many." *Zeitschrift fur Unternehmensgeschichte* 54 (1): 50–72.

Fear, Jeffrey, and Christopher Kobrak. 2010. "Banks on Board: German and American Corporate Governance, 1870–1914." *Business History Review* 84 (4): 703–36.

Feldenkirchen, Wilfried. 1991. "Banking and Economic Growth: Banks and Industry in Germany in the Nineteenth Century and Their Changing Relationship during Industrialisation." In *German Industry and German Industrialisation: Essays in German Economic and Business History in the Nineteenth and Twentieth Centuries*, edited by W. R. Lee, 116–47. New York: Routledge.

Fohlin, Caroline. 2007. *Finance Capitalism and Germany's Rise to Industrial Power*. Studies in Macroeconomic History. Cambridge, UK: Cambridge University Press.
Fohlin, Carolin. 2016. "Financial Systems." In *Handbook of Cliometrics*, edited by Claude Diebolt and Michael Haupert, 393–430. Heidelberg: Springer.
Franks, Julian, Colin Mayer, and Hannes F. Wagner. 2006. "The Origins of the German Corporation—Finance, Ownership and Control." *Review of Finance* 10 (4): 537–85.
Gelman, Sergey, and Carsten Burhop. 2008. "Taxation, Regulation and the Information Efficiency of the Berlin Stock Exchange, 1892–1913." *European Review of Economic History* 12 (1): 39–66.
Gerschenkron, Alexander. 1962. *Economic Backwardness in Historical Perspective: A Book of Essays*. Cambridge: Belknap Press.
Guinnane, Timothy W. 2002. "Delegated Monitors, Large and Small: Germany's Banking System, 1800–1914." *Journal of Economic Literature* 40 (1): 73–124.
Guinnane, Timothy, Ron Harris, Naomi R. Lamoreaux, and Jean-Laurent Rosenthal. 2007. "Putting the Corporation in Its Place." *Enterprise and Society* 8 (3): 687–729.
Guinnane, Timothy, and Susana Martínez-Rodríguez. 2015. "Choice of Enterprise Form: Spain, 1886–1936." Yale University Economic Growth Center Discussion Paper 1049.
Guo, Re-Jin, Baruch Lev, and Charles Shi. 2006. "Explaining the Short- and Long-Term IPO Anomalies in the US by R&D." *Journal of Business Finance and Accounting* 33 (3–4): 550–79.
Hahn, Gerhard. 1958. *Ursachen von Unternehmensmisserfolgen: Ergebnisse von Untersuchungen besonders im rheinischen Industriebezirk.* Cologne: Deutsche Industrieverlags-GmbH.
Hornung, Erik. 2015. "Railroads and Growth in Prussia." *Journal of the European Economic Association* 13 (4): 699–736.
Ibbotson, Roger G. 1975. "Price Performance of Common Stock New Issues." *Journal of Financial Economics* 2 (3): 235–72.
Lehmann, Sibylle. 2014. "Taking Firms to the Stock Market: IPOs and the Importance of Large Banks in Imperial Germany." *Economic History Review* 67 (1): 92–122.
Lehmann-Hasemeyer, Sibylle, and Jochen Streb. 2016. "The Berlin Stock Exchange in Imperial Germany: A Market for New Technology?: Dataset." *American Economic Review.* http://dx.doi.org/10.1257/aer.20150626.
Levine, Ross. 2002. "Bank-Based or Market-Based Financial Systems: Which Is Better?" *Journal of Financial Intermediation* 11 (4): 398–428.
Ljungqvist, Alexander P. 1997. "Pricing Initial Public Offerings: Further Evidence from Germany." *European Economic Review* 41 (7): 1309–20.
Logue, Dennis E. 1973. "On the Pricing of Unseasoned Equity Issues: 1965–1969." *Journal of Financial and Quantitative Analysis* 8 (1): 91–103.
Loughran, Tim, and Jay R. Ritter. 1995. "The New Issues Puzzle." *Journal of Finance* 50 (1): 23–51.
Moral, Felix. 1914. *Aktienkapital und Aktien-Emissionskurs bei industriellen Unternehmungen*. Munich: Duncker & Homblot.
Moser, Petra. 2012. "Innovation without Patents: Evidence from World's Fairs." *Journal of Law and Economics* 55 (1): 43–74.
Müller, Elisabeth, and Frank Reize. 2010. "Finanzierung von Innovationen in kleinene und mittleren Unternehmen." In *Finanzierung von Innovationen*, edited by Gert Kollmer-von Oheimb-Loup and Jochen Streb, 155–68. Ostfildern: Jan Thorbecke Verlag.
Neuburger, Hugh, and Houston H. Stokes. 1974. "German Banks and German Growth, 1883–1913: An Empirical View." *Journal of Economic History* 34 (3): 710–31.
Pástor, Luboš, Lucian A. Taylor, and Pietro Veronesi. 2009. "Entrepreneurial Learning, the IPO Decision, and the Post-IPO Drop in Firm Profitability." *Review of Financial Studies* 22 (8): 3005–46.
Pierenkemper, Tony. 1990. "Zur Finanzierung von industriellen Unternehmensgrundungen im 19. Jahrhundert-mit einigen Bemerkungen uber die Bedeutung der Familie." In *Zur Geschichte der Unternehmensfinanzierung*, edited by Dietmar Petzina, 69–98. Berlin: Duncker & Humblot.
Proettel, Thorsten. 2013. "Die Darlehensvergabe der Oberamtssparkasse Kirchheim unter Teck 1907 bis 1913: Eine Sparkasse als regionale Finanzierungsquelle für Gewerbe und Infrastruktur." *Zeitschrift für Unternehmensgeschichte* 58: 3–27.
Rajan, Raghuram G., and Luigi Zingales. 2003. "The Great Reversals: The Politics of Financial Development in the Twentieth Century." *Journal of Financial Economics* 69 (1): 5–50.
Reilly, Frank K. 1973. "Further Evidence on Short-Run Results for New Issue Investors." *Journal of Financial and Quantitative Analysis* 8 (1): 83–90.
Richter, Ralf, and Jochen Streb. 2011. "Catching-Up and Falling Behind: Knowledge Spillover from American to German Machine Toolmakers." *Journal of Economic History* 71 (4): 1006–31.
Ritter, Jay R. 1991. "The Long-Run Performance of Initial Public Offerings." *Journal of Finance* 46 (1): 3–27.

Ritter, Jay R., and Ivo Welch. 2002. "A Review of IPO Activity, Pricing, and Allocations." *Journal of Finance* 57 (4): 1795–828.

Schankerman, Mark, and Ariel Pakes. 1986. "Estimates of the Value of Patent Rights in European Countries during the Post-1950 Period." *Economic Journal* 96 (384): 1052–76.

Stoll, Hans R., and Anthony J. Curley. 1970. "Small Business and the New Issues Market for Equities." *Journal of Financial and Quantitative Analysis* 5 (3): 309–22.

Streb, Jochen. 2016. "The Cliometric Study of Innovations." In *Handbook of Cliometrics*, edited by Claude Diebolt and Michael Haupert, 447–68. Heidelberg: Springer.

Streb, Jochen, Jorg Baten, and Shuxi Yin. 2006. "Technological and Geographical Knowledge Spillover in the German Empire 1877–1918." *Economic History Review* 59 (2): 347–73.

Streb, Jochen, Jacek Wallusch, and Shuxi Yin. 2007. "Knowledge Spill-Over from New to Old Industries: The Case of German Synthetic Dyes and Textiles (1878–1913)." *Explorations in Economic History* 44 (2): 203–23.

Sullivan, Richard J. 1994. "Estimates of the Value of Patent Rights in Great Britain and Ireland, 1852–1876." *Economica* 61 (241): 37–58.

Weigt, Anja. 2005. *Der deutsche Kapitalmarkt vor dem ersten Weltkrieg Grunderboom Grunderkrise und Effizienz des deutschen Aktienmarktes bis 1914.* Frankfurt/Main: Fritz Knapp Verlag.

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4. Nikolaus Wolf. 2021. Deutschland in der ersten Globalisierung. *Wirtschaftsdienst* **101**:4, 254-258. [Crossref]
5. Eric Monnet, François R. Velde. Money, banking, and old-school historical economics 335-364. [Crossref]
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7. Sibylle Lehmann-Hasemeyer, Jochen Streb. 2020. Discrimination against Foreigners: The Wuerttemberg Patent Law in Administrative Practice. *The Journal of Economic History* **80**:4, 1071-1100. [Crossref]
8. Sturla Fjesme, Neal Galpin, Lyndon Moore. 2019. An efficient market? Going public in London, 1891–1911. *The Economic History Review* **72**:3, 1008-1027. [Crossref]
9. Franz X. Hof, Klaus Prettner. 2019. The quest for status and R&D-based growth. *Journal of Economic Behavior & Organization* **162**, 290-307. [Crossref]
10. Walter Jansson. 2018. Stock markets, banks and economic growth in the UK, 1850–1913. *Financial History Review* **25**:3, 263-296. [Crossref]
11. Sibylle Lehmann-Hasemeyer, Jochen Streb. 2018. Does Social Security Crowd Out Private Savings? The Case of Bismarck's System of Social Insurance. *European Review of Economic History* **22**:3, 298-321. [Crossref]
12. Walter Jansson. 2018. Stock Markets, Banks and Economic Growth in the UK, 1850-1913. *SSRN Electronic Journal* . [Crossref]
13. Jens Günther. 2017. Capital market effects around dividend announcements: an analysis of the Berlin stock exchange in 1895. *Accounting History Review* **27**:3, 249-278. [Crossref]
14. Francesco Cinnirella, Jochen Streb. 2017. The role of human capital and innovation in economic development: evidence from post-Malthusian Prussia. *Journal of Economic Growth* **22**:2, 193-227. [Crossref]
15. Alexander Donges, Jean-Marie A. Meier, Rui Silva. 2017. The Impact of Institutions on Innovation. *SSRN Electronic Journal* **101**. . [Crossref]