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The Hazard of Merger by Absorption – Why Some Knappschaften Merged and Others Did not: 1861–1920

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Tobias Alexander Jopp[1]

The Hazard of Merger by Absorption – Why Some *Knappschaften* Merged and Others Did not: 1861–1920

Abstract

By the mid-19th century, following the Prussian mining reform, German miners' combined mutual health and pension funds took on the characteristics of social insurance and underwent a concentration process driven by mergers, liquidations, and unequal internal growth. This paper investigates the determinants of mergers by absorption among Prussian funds combined with quantitative evidence from a regression model, provides new insights into the first social-insurance merger wave in Germany. While most contemporary sources convey the impression that funds were merged to stabilize the entire insurance scheme by sorting out actuarially unviable and financially distressed funds, statistical evidence suggests that funds were absorbed over time primarily because they offered advantages to the absorbing fund and, hence, were quite attractive targets.

JEL Classification: C41, G22, G23, I31, N33

Keywords: Competing risk; financial distress; insurance; Knappschaft; liquidation; merger; mining

March 2011

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1. Introduction

This paper investigates the determinants of mergers among Prussian miners' social-insurance funds between 1861 and 1920. The so-called *Knappschaften*, the miners' mutual insurance funds, provided compulsory insurance on a pay-as-you-go basis. The insurance contract obligated each miner to make a regular contribution to his fund, and, in return, he would receive insurance benefits conditional on the occurrence of particular events. *Knappschaften* (henceforth abbreviated with KVs for German *Knappschaftsvereine*) were to insure against sickness, injuries, invalidity, survivorship, and—implicitly—old age. The corresponding benefit package included income-replacement benefits, such as sick pay and pensions, and in-kind benefits such as medical treatment.

Focusing on the formative period of the German welfare state, this investigation is motivated by an important stylized fact: Starting in the 1870s, absolute and relative concentration among KVs steadily increased. The underlying concentration process was not driven just by unequal internal growth, but by liquidations and mergers in particular. Aside from the fact that we can observe this wave of external growth among those pioneers of social insurance, the decision-making process itself—involving miners, their employers, the state, as well as contemporary observers as external opinion makers—is still pretty much a black box.

Contemporary observers and the recent economic literature suggest two well-known motives for insurance mergers during the period this paper studies. On the one hand, mergers might have been conducted to take financial pressure off KVs. Some KVs were struggling due to the structural decline of the mining area, to which they were tied, and due to business-cycle fluctuations or actuarial disadvantages, such as being too small or lacking actuarial expertise. Both facts, it is surmised, eventually drove the KVs and their insurants to financial disaster. I call this the 'rescue hypothesis.' From this perspective, mergers were conducted in order to stabilize the job-related insurance scheme in Prussian mining as a whole. This could have worked only if at least one of the following conditions was fulfilled: (i) Miners and mine owners, who, together, self-managed their KVs, felt highly responsible for their fellow KVs and unanimously considered it an act of solidarity to help financially distressed KVs; and (ii) the mining administration, hence the industry regulator, forced mergers on KVs according to its own aims and regardless of whether or not miners and mine owners agreed. On the other hand, mergers might have been conducted simply because the absorbing KV aimed to seek growth opportunities and advantages—for example, in the form of cost reductions by improving one's own actuarial fundamentals. I call this the 'self-interest' hypothesis. Here, solidarity is not required. Rather, the regulator would have been required to tolerate any merger con-

ducted or refused. A third hypothesis, however, might be that mergers, and maybe even liquidations, were the consequence of accidental, ad-hoc decisions rather than planned and conscious action.

In order to open the black box of mergers among KVs, this investigation combines a qualitative analysis of contemporary economic arguments for mergers and statistical evidence on the determinants of the concentration process. The basic assumption of this paper that external growth was due mainly to an economic rationale seems to be justified for two reasons. First, this view dominates the contemporary literature on KVs. Second, source material on board meetings, which would directly indicate whether decisions to merge or to liquidate were done for non-economic reasons, is currently unavailable. Accordingly, the analysis is done in four consecutive steps: First, data sources are explained. Second, in order to convey an impression of the basic economic and social conditions under which KVs operated, the German mining industry's development is briefly reviewed and linked with an overview of the KVs. Third, contemporary arguments for mergers and concentration are evaluated. Fourth, an empirical survival model, based on Fine and Gray's (1999) competing risk approach, is presented, yielding additional statistical insights.

Most contemporary sources convey the impression that KVs were merged to stabilize the entire insurance scheme by sorting out actuarially unviable and financially distressed funds. In contrast, statistical evidence suggests that the KVs were absorbed over time primarily because they offered advantages to the absorbing KVs and, hence, were quite attractive targets. This contradicts the rescue hypothesis and the idea of cross-KV solidarity.

2. Data sources

This analysis draws mainly on the *Statistik der Knappschaftsvereine des preussischen Staates*, henceforth referred to as KV statistics. The Prussian ministry of trade and commerce compiled and published these statistics starting in 1854, reporting data for 1852.[1] Beginning in 1862, annual data were published regularly, with each year's publication reporting information on the preceding year. For the years 1921 and 1922, information is not available. In 1923, all German KVs merged into the *Reichsknappschaft*. What the ministry of trade and commerce actually compiled and published were the official reports of the KVs, which they were obliged to send to the ministry. Thus, miners and mine owners, who together operated their KVs, relied on a pool of quantitative information addressing past experience. In particular, the extent of quantitative material on one's own past experience grew from year to year. Data

[1] Bavarian and Saxonian Knappschaften were excluded.

cover the entire population of 103 Prussian KVs operating within the period 1861-1920 and provide a broad range of information on memberships, revenues and expenditures.[2]

Information on mergers and liquidations within the observation period are taken from Jopp (2010), who provides a basic overview of the 20 mergers (name of involved KVs, their location, year of merger, size, pensioners-to-contributors ratio in the year prior to the merger, and, as appropriate, the name of the newly created KV). In particular, Jopp distinguishes two types of mergers. The former (type A) was the more frequent and happened when one or more KVs were merged into another fund that had existed before the merger and continued to exist afterwards.[3] The latter (type B) happened when two or more KVs merged to create a new fund.

3. German mining and the *Knappschaften* – an overview

By the middle of the 1850s, German miners could already look back at 600 years of experience with mutuality in risk provision. Almost from the start, mine owners were part of the system as sponsors. As a consequence of the *Knappschaft* law of 1854, both miners and their employers entered into a new era, one of 'social insurance'. KVs pioneered the field of organizing social insurance against the contingencies of life, the consequences of which everyone feared, and no one could shoulder on his own. There is no doubt that mining, especially deep mining for coal, was among the most perilous occupations connected with a high ex ante probability of becoming involved in accidents and suffering from severe chronic diseases (e.g., silicosis) or epidemics (e.g., hookworm). The key reason for these health issues was the lack of safety measures and hygiene, issues that were put on the agenda only little by little.[4] Since KVs were an integral part of the German mining industry, their business policy and the economic and social challenges they faced can only be understood against the background of the industry's secular trends and peculiarities. Thus, some general contextualization seems to be in order.

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[2] The data set is divided into three samples. The basic sample consists of the cohort of KVs that were still in operation in 1920 and, thus, survived over the observation period. Sample two is made up of all KVs that ceased operation before 1920 because they were absorbed by another KV or, together with another KV, merged into a newly-created fund. Sample three covers the remainder of KVs that exited the market because of terminal liquidation.

[3] Tobias A. Jopp, Ein risikoreiches Geschäft? Internes und externes Wachstum als risikopolitische Instrumente im preußischen Knappschaftswesen, 1854-1923, in: *Berufliches Risiko und soziale Sicherheit. Beiträge zur Tagung „Vergangenheit und Zukunft sozialer Sicherungssysteme am Beispiel der Bundesknappschaft und ihrer Nachfolger" im Deutschen Bergbau-Museum Bochum, 8. und 9. Oktober 2009*, ed. by Christoph Bartels, Bochum 2010, 189-224, 189-192,

[4] Lars Bluma, Der Hakenwurm an der Ruhr. Umwelt, Körper und soziale Netzwerke im Bergbau des Kaiserreichs, in: *Der Anschnitt* 61 (2009), 314-329; Josef Boyer, *Unfallversicherung und Unternehmer im Bergbau – Die Knappschafts-Berufsgenossenschaft 1885-1945*, München 1995.

3.1. Industry structure and administrative units

German mining might, at first, be associated with coal, and particularly hard coal. In the nineteenth century, hard coal certainly became the single most important natural resource, and most miners—hence most KV members—were engaged in extracting it. However, extractive activities concentrated on a number of resources, diverse in their properties and, thus, in their challenges for the production process. In the following, I refer to these various resources as 'subsectors' of the mining sector. According to German national statistics, we can identify the following subsectors: (i) hard coal, (ii) brown coal, (iii) iron ore, (iv) miscellaneous ores, (v) halite, (vi) salts, (vii) pyrite, and (viii) the rest.[5]

Based on that structure, the Prussian KV statistics, introduced in the previous section, identify the number of active miners—in my terms, 'contributors'—per subsector per KV. It does so for (i) to (vi) and adds additional categories, namely stone pits, steelworks and other smelting works (for zinc ore and so on).[6] Hence, on aggregate, KVs reflected industry structure in terms of membership according to Table 1. The share of hard-coal miners, for example, increased from 55.4 percent of all contributors in 1867 to about 75 percent in 1916. Among the 103 Prussian KVs, 18 funds insured predominantly hard-coal miners. There are not many cases in which a KV's membership arose from only one subsector—KVs tied to salines or many steelworks, for example. In addition, 15 KVs, not ascribed to one of the mentioned subsectors, can only be labeled as mixed ones.

The German mining sector had its own administrative foundation. The parts of Prussia's territory where mining took place were divided into five mining-administration regions (*Oberbergamtsbezirke*): (1) Bonn: mostly congruent with the province Rheinland and accounting for the Saar as well as Aachen coalfields; (2) Breslau: the coalfields of Upper and Lower Silesia were located here; (3) Clausthal: congruent with the province Hannover and encompassing the Harz coal and ore fields; (4) Dortmund: mostly congruent with the province Westphalia and containing the Ruhr coalfields; and (5) Halle: encompassing the province Saxony and containing important brown-coal and ore fields. Within the geographical boundaries of these administrative units, the KVs were operated locally—e.g., for a small coal or ore

[5] Wolfram Fischer (ed.), *Statistik der Bergbauproduktion Deutschlands 1850-1914*, St. Katharinen 1989; Wolfram Fischer (ed.), *Statistik der Montanproduktion Deutschlands 1915-1985*, St. Katharinen 1995. Miscellaneous ores include zinc, lead, copper, silver, manganese, mercury, cobalt, nickel, antimony, arsenic, and alum ores. Salts include potash salt, kainite, and boracite. The rest includes, for example, tarmac, tungsten, graphite, and tin.

[6] Rudolf Klostermann, *Das Allgemeine Berggesetz für die preußischen Staaten vom 24. Juni 1865, nebst Einleitung und Kommentar*, Berlin 1866, 302-303 (§ 166). Steelworks and other smelting works were deprived of the mining administration's control during the Prussian mining reform, 1851-1865, and assigned to trade control. This principally meant losing access to *Knappschaft* insurance. However, related enterprises that had already existed before 1865, when the Prussian general mining law (*Allgemeines Berggesetz*) was enacted, could choose to continue membership in *Knappschaft* insurance. A number indeed did so.

field (and all enterprises there) or a particular mine—or regionally—for a larger mining area (and all the enterprises there).

Table 1. The percentage shares of the Knappschaften's contributors by subsectors

Year	Hard coal	Brown coal	Iron ore	Misc. ores	Stones	Halite	Salines	Steelworks
1867	55.4	8.6	8.9	13.4	1.1	0.4	0.8	11.4
1871	55.8	7.1	9.0	15.2	0.8	0.3	0.6	11.2
1881	57.2	7.0	8.6	15.0	0.8	0.9	0.4	10.1
1891	62.5	7.4	5.7	11.4	1.0	1.4	0.3	10.3
1901	68.4	8.1	3.7	7.7	0.9	2.1	0.2	8.9
1911	73.4	6.8	2.5	4.9	0.8	4.2	0.6	6.8
1916	74.7	6.1	3.0	5.0	0.5	2.9	0.1	7.7
1920	73.4	10.4	2.3	3.2	0.2	4.6	0.1	5.8
Number of KVs with clear focus on the respective product								
1861-1920	18	9	11	14	5	2	12	17

Source: Own calculation based on Ministerium für Handel und Gewerbe (1862-1922), *Statistik der Knappschaftsvereine des preussischen Staates*, in: Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate, 10-70.

3.2. Production, productivity and technology

To begin with, aggregate figures on the industrializing German economy draw a picture of aggregate growth. Between 1851 and 1870, net national product (NNP) grew at an annual rate of 1.56 percent. During the German Reich until 1913, NNP grew even faster, at an annual rate of 2.67 percent.[7] Yet, due to World War I and post-war inflation, the economy contracted in the following years. For 1914 to 1920, Ritschl and Spoerer estimate annual growth of gross national product (GNP)—not NNP— at -3.76 percent during 1914-1920.[8] The 'leading sector complex' of the railroad and heavy industries, replaced after 1890 by the chemical industry and electrical and mechanical engineering, is commonly identified as one of the most important drivers of that secular pre-war growth.[9]

Table 2. Output and labor input in Prussian mining as a? percent of German totals

[7] Calculated with data from Carsten Burhop/Guntram B. Wolff, A compromise estimate of German net national product, 1851-1913, and its implications for growth and the business cycle, in: *Journal of Economic History* 65 (2005), 613-657.

[8] Albrecht Ritschl/Mark Spoerer, Das Bruttosozialprodukt in Deutschland nach den amtlichn Volkseinkommens- und Sozialproduktsstatistiken 1901-1995, in: *Jahrbuch für Wirtschaftsgeschichte/ Economic History Yearbook* 1997/2 (1997), 27-54, 51. Data on NNP during 1914-1920 are not available.

[9] Carl-Ludwig Holtfrerich, *Quantitative Wirtschaftsgeschichte des Ruhrkohlenbergbaus im 19. Jahrhundert – Eine Führungssektoranalyse*, Dortmund 1973; Richard Tilly, *Vom Zollverein zum Industriestaat*, München 1990, 50-58.

	1861		1887		1913		1920	
	Output	Work-force	Output	Work-force	Output	Work-force	Output	Work-force
(1) In million tons / in 1,000 employed miners								
Hard coal	11.7	68.2	54.6	191.3	180.1	640.2	127.0	708.0
Brown coal	3.3	10.7	12.7	23.3	70.0	59.9	91.9	133.6
Ores	1.5	35.3	5.4	65.8	7.2	57.6	5.5	55.1
(2) In per cent of German totals								
Hard coal	83.2	78.9	90.5	88.0	94.7	80.3	96.7	99.2
Brown coal	71.8	57.3	79.9	79.2	93.3	77.2	82.1	97.9
Ores	62.5	72.8	49.5	87.6	19.3	68.6	63.2	95.0

Note: Ores include iron, zinc, lead, and copper ores.
Source: Data from Fischer, *Bergbauproduktion* (cf. n. 7), and Fischer, *Montanproduktion* (cf. n. 7).

Led by Prussia and its hard-coal deposits, the picture of the German mining sector's long-term prosperity develops as follows. As early as 1818, hard-coal production exceeded one million tons in Prussia.[10] In 1861, production had already reached 11.7 million tons, accounting for about 83 percent of German hard-coal output. Both output in tons and the percentage share of the entire economy's production increased further towards 1913. In particular, aggregate Prussian production grew at an average annual rate that exceeded the growth of the economy as measured by the NNP; it grew at 8.59 percent per year during 1851-1870 and 4.87 percent during 1871-1913. Moreover, while Prussian brown-coal production was about 3.3 million tons in 1861 (57.3 percent of German production), it reached 70 million tons in 1913 and 92 million tons in 1920. However, the series on aggregate ore production tells a slightly different story in that tons of ore extracted indeed increased toward 1913, but Prussia's share in German ore production decreased. On a disaggregated level, regarding mining-administration regions, some ores were subject to long-term stagnation in production—copper in Bonn (throughout the entire period) or lead ore in Clausthal (starting in 1882)—or decline (lead ore in Bonn starting in 1882 and iron ore in Breslau starting in 1885).

Apart from the path-breaking technological innovation of deep-coal mining by use of vertically sunk shafts (implemented in the late 1830s) and feedback effects from other sectors, it is commonly agreed that the Prussian mining reform (1851-1865) was responsible for the take-off and long-term growth of the German mining industry. The reform fits well into the picture of a general liberal 'turn in economic and financial policy' in Germany, drawn, for example, by Tilly or Fischer.[11] Until the reform, the entire mining sector was under direct

[10] Hubert Kiesewetter, *Industrielle Revolution in Deutschland 1815-1914*, Frankfurt am Main 1989, 230.
[11] Wolfram Fischer, Das wirtschafts- und sozialpolitische Ordnungsbild der preußischen Bergrechtsreform 1851-1865, *Zeitschrift für Bergrecht* 102 (1961), 181-189; Tilly, *Vom Zollverein zum Industriestaat* (cf. n. 11), 48.

control of the mining administration according to absolutist-mercantilist policy. But with the reform, mine owners received entrepreneurial freedom very quickly, with, for example, the design of labor contracts, investment decisions or the right to exploit deposits underground even if one did not own the land at the surface (*Bergbaufreiheit*). According to liberal ideals, the regulatory environment in which mining entrepreneurs acted can be labeled as very investment-friendly. Considering the fact that sinking shafts and developing resource deposits was a very risky, long-term undertaking requiring huge financial input, the reform liberated very productive forces.

The expansion of production capacity can be measured in four ways: by the number of mines, by average mine size, by the change in the number of installed steam engines or, respectively, steam engine horsepower (or horsepower of electrical engines); and by increases in the workforce. First, the overall number of mines in Prussia was 1,902 in 1867, peaked in 1873 with 2,675, and, finally, fell to 1,673 in 1920.[12] These numbers indicate a long-term reduction of mine capacity after the 1873 crisis (*Gründerkrise*). Though, second, this downward trend in the number of mines was accompanied by an increase in average mine size in most subsectors. Third, with regard to hard coal mining, the number of installed steam engines—for purposes of drainage or raising coal from increasing depths, for example—increased notably. Installed horsepower in Ruhr coal mining, for example, amounted to 69,000 in 1871 and increased to 995,000 by 1909.[13] Fourth, as Table 2 shows, production capacity in hard coal, brown coal and ore mining in terms of the workforce increased notably, as well. The expansion of the workforce is probably the best indicator of production-capacity expansion since mining was a very labor-intensive activity despite various approaches to mechanizing production and implementing labor-saving techniques.[14] Table 2 illustrates the extensive growth of labor input. Among the main hard-coal fields, those in the Ruhr area consumed the most labor. Prosperity induced migration from areas such as the eastern parts of the Reich, which, in turn, had positive effects on the availability of skilled labor.

In line with the expansion of the mining sector was wage growth. Walther G. Hoffmann estimates average annual wage income across all subsectors and regions at 523 marks in 1861 and 1,496 marks in 1913, which yields a trend growth of 2.04 percent per year. Wages nonetheless varied over the business cycle, as the coefficient of variation of 25.5 percent of

[12] Calculated from Ministerium für Handel und Gewerbe, *Statistik* (see Table 1).
[13] Ministerium für Handel und Gewerbe, Statistischer Teil, in: *Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate* 20 and 52 (1872 and 1910).
[14] Uwe Burghardt, *Die Mechanisierung des Ruhrbergbaus: 1890-1930*, München 1995, 137-144.

Hoffmann's wage series implies.[15] At the coal-field level, in particular, there were clear wage differentials. Take, for example, the case of hard-coal mining in the Ruhr, the Saar and Silesia. While a miner in the Ruhr earned an average of 772 marks in 1886 and a miner in the Saar earned 809 marks, one in Upper Silesia earned only 490 marks. As of 1893, average annual earnings in the Ruhr exceeded those in the Saar, and the differential in Silesia persisted.[16]

Labor productivity increased in the long term in almost all subsectors, even though there were also longer stagnant periods as well as a decline in tons of resources mined per employee. Besides labor productivity, total factor productivity (TFP) is an alternative measure of productivity. Recent findings on a constant TFP in the Ruhr between 1881 and 1913 suggest that worsening geological conditions had offset the technological progress from a number of important production process-related innovations. Those innovations affected, in particular, the transport of coal from the coalface to the surface (e.g., the mechanical conveyor belt, slides or underground locomotives), but not the cutting of the coal itself (coal cutting supported with mechanical hammers).[17] This should be considered against the background that geological conditions—measured, for example, by the average depth at which extraction took place—worsened over time, at least in hard-coal mining, and, thus, for about 55 to 75 percent of Prussian miners (see Table 1). According to Huske's data on the Ruhr coalfields, I have estimated the average shaft's depth at 134 meters in 1850, 172 meters in 1861, 523 meters in 1913, and 555 meters in 1920.[18] Clark and Jacks, for example, make the empirical case for depth being of high importance for TFP in coal mining.[19]

Mining was among the most hazardous occupations at the time, exceeded only by working as haulers, millers or in quarries.[20] According to Boyer, it was the *Knappschafts-Berufsgenossenschaft*, one of the many employers' liability insurance associations carrying out Bismarck's accident insurance law (1884), that compiled substantive statistics on accidents in German mining. Those statistics show that the number of first-time reimbursed cases

[15] Walter G. Hoffman, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin 1965, 461.
[16] Ministerium für Handel und Gewerbe, Statistische Mitteilungen über die beim Bergbau Preußens gezahlten Arbeitslöhne und erzielten Arbeitsleistungen, in: *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate* 37-70 (1886-1922).
[17] Burghardt, *Mechanisierung* (cf. n. 15); Carsten Burhop/Thorsten Lübbers, Cartels, managerial incentives, and productive efficiency in German coal mining, 1881-1913, in: *Journal of Economic History* 69 (2009), 500-527, 510.
[18] Joachim Huske, *Die Steinkohlenzechen im Ruhrrevier – Daten und Fakten von den Anfängen bis 1907*, Bochum 1998.
[19] Gregory Clark/David Jacks, Coal and the Industrial Revolution, 1700-1869, in: *European Review of Economic History* 11 (2007), 39-72.
[20] Boyer, *Unfallversicherung* (cf. n. 5), 39.

of accident per 1,000 insured miners in one year amounted to 6.6 in 1886 and increased to about 15 in 1913.[21] Across all occupations, however, that number amounted to merely 2.83 in 1886, 6.97 at its peak in 1905, and 4.80 in 1913.[22]

In addition to those figures, crude death rates also suggest that mining was extremely hazardous. Table 3 reports, on the one hand, the number of deaths among 1,000 active KV members per subsector and, on the other hand, the deaths per 1,000 in the German population. This comparison is, of course, imperfect since national figures do include more than just the economically active male population. Nonetheless the rates give an indication of the comparatively high probability of death while working as a miner, as compared to the national average. Figures also indicate differences across subsectors, diminishing rates toward World War I, and a heavy increase in rates during war. Diminishing rates may have been a result of improved medical treatment or improved work safety, although Boyer concludes that, since 1871, safety regulations had not improved much beyond pre-Reich standards.[23]

Table 3. Death of active miners per 1,000 per subsector, compared to the national level

Year	Crude death rate of active miners by subsector					Crude death rate of the Population
	Hard coal	Brown coal	Ores	Salt	Steelworks	
1871	13.7	10.4	12.1	10.1	11.9	2.7
1881	10.1	8.1	12.6	7.0	7.6	2.5
1891	7.9	6.2	9.7	6.7	9.6	2.3
1901	7.3	8.2	8.2	7.4	6.2	2.1
1911	5.4	7.5	7.3	4.1	4.6	1.7
1916	27.2	18.2	15.0	18.6	21.3	1.9
1920	8.9	5.9	5.9	8.1	5.0	1.5

Note: The crude death rate per KV per year is [(deaths of active miners/sum of active miners)*1,000].
Source: Own calculation based on Ministerium für Handel und Gewerbe, *Statistik* (see Table 1), and Franz Rothenbacher, *The European Population 1850-1945*, Houndmills 2002, 288-291.

3.3. Features of Knappschaften

Nineteenth-century observers often interpreted early voluntary associations of miners in the Middle Ages as reflecting the very uniqueness of their occupation, the unparalleled hazards to health and the ability to work, and, thus, the above-average need for income protection.[24]

[21] Boyer, *Unfallversicherung* (cf. n. 5), 38.
[22] David Khoudour-Castéras, Welfare State and Labor Mobility: The Impact of Bismarck's Social Legislation on German Emigration before World War I, in: Journal of Economic History (2008), 68, 211-243, 235.
[23] Boyer, *Unfallversicherung* (cf. n. 5), 116.
[24] Ulrich Lauf, Bruderschaft und Büchsengeld: eine Untersuchung zu den mittelalterlichen Wurzeln unserer Sozialversicherung, in: *Wege zur Sozialversicherung* (2003), 176-188. Actually, the formation of associations that soon became known as the *Knappschaft*en well matches the recently drawn picture of emerging collective

However, there is no doubt that miners felt the need to jointly shoulder financial uncertainty due to erratic, immediate income losses resulting from sickness or injuries long before this study's observation period. Accordingly, miners benefited from several sources of income replacement right from the start of the KVs' history: (i) daily sick pay in the case of temporary sickness; (ii) medical treatment; (iii) lifetime invalidity pensions in the case of permanent incapacitation; and (iv) survivorship pensions in the case of the breadwinner's death.[25] Until the end of the sixteenth century, however, KVs came across as charitable organizations providing very moderate benefits in the case of need and so long as the cash box allowed. A legal right to receive benefits commensurate with contributions paid did not exist. When the absolutist-mercantilist regime emerged, charity was by patronage through the sovereign, who assured subsistence by providing the 'wage by mercy' (*Gnadenlohn*) in case of the inability to work.[26]

The reform of Prussian mining legislation between 1851 and 1865 then shaped the KVs' benefit scheme towards job-related insurance. KVs had already operated with compulsory membership and mandatory contributions to be paid by miners and mine owners. The *Knappschaft* law of 1854 introduced, in addition, legal claims and, thus, some kind of actuarial relationship between contributions and benefits.[27] While miners and their employers were now free to manage the KVs, the mining administration, though it lost direct control over all aspects of the business, retained its supervisory role and still functioned as the industry regulator. KVs operated either a benefit scheme for a particular area (e.g., the *Märkische Knappschaft* in the Ruhr), and for which no other KV was allowed to compete, or for a particular mine, mining enterprise or steelworks (e.g., the *Georgs-Marien-Hütte* in the Ruhr). Thus, the

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action in Europe at the time, aiming especially to provide working people and their dependants with a kind of–often occupation- or profession-specific–social safety net; see Margarete Wagner-Braun, *Zur Bedeutung berufsständischer Krankenkassen innerhalb der privaten Krankenversicherung in Deutschland bis zum Zweiten Weltkrieg – Die Selbsthilfeeinrichtungen der katholischen Geistlichen*, Stuttgart 2002; Sheilagh Ogilvie, Guilds, efficiency, and social capital: evidence from German proto-industry, in: *Economic History Review* 57 (2007), 286-333; Tine De Moor, The Silent Revolution: A New Perspective on the Emergence of Commons, Guilds, and other Forms of Corporate Collective Action in Western Europe, in: *The International Review of Social History* 53 (2008), 175-208.

[25] Königreich Preußen, *Gesetz, betreffend die Vereinigung der Berg-, Hütten- und Salinen- und Aufbereitungs-Arbeiter in Knappschaften, für den ganzen Umfang der Monarchie, vom 10. April* 1854, Essen 1855; Klostermann, *Das Allgemeine Berggesetz* (cf. n. 7); Bartels et al., *Vergangenheit und Zukunft* (cf. n. 1).

[26] Wilhelm Bülow, *Das Knappschaftswesen im Ruhrkohlenbezirk bis zum allgemeinen preußischen Berggesetz vom 24. Juni 1865*, Borna-Leipzig 1905, 32-65.

[27] Klaus Tenfelde, Die Knappschaftsversicherung und die Wurzeln der Sozialversicherung in Deutschland, in: *150 Jahre Preußisches Knappschaftsgesetz*, ed. by Bundesknappschaft, Bochum 2004; Andreas Bingener, Zur Vorgeschichte und zu den Auswirkungen des Preußischen Knappschaftsgesetzes von 1854, in: *Berufliches Risiko und soziale Sicherheit. Beiträge zur Tagung „Vergangenheit und Zukunft sozialer Sicherungssysteme am Beispiel der Bundesknappschaft und ihrer Nachfolger" im Deutschen Bergbau-Museum Bochum, 8. und 9. Oktober 2009*, ed. by Christoph Bartels, Bochum 2010, 29-46. Tobias A. Jopp, The Welfare State Evolves: German Knappschaften, 1854-1923, in: *Business and Economic History On-Line* (2010), 8.

decisions about continuation of the insurance funds' operation must have been made with the structural development of the particular coal, ore or salt fields—to which the KVs were directly tied[28]—in mind.

Table 4 displays aggregate membership information on contributing miners and pension recipients, as well as aggregate expenditure information on daily sick pay, medical treatment and pensions for invalids and survivors.[29] Columns (1) and (2) show the long-term expansion of Prussian KVs in terms of members. This, in turn, reflects the rapid growth of the Prussian mining sector addressed above. Comparing 1861 and 1920, the contributor base—i.e., the financial power of the KVs—increased by about 753 percent, whereas the number of pensioners to be financed increased at an even higher rate, implying an increasing financial burden put on the average contributor. However, while there were always more survivors than invalidity pensioners, invalids were far more costly, as columns (7) and (8) show. At the minimum, about 47 to 50 percent of pension expenditure was for invalidity pensions.[30] On the whole, aggregate expenditure data indicate a great expansion of social spending within theKVs' benefit scheme. This applies to all main claims categories, including sickness-related benefits.[31] Extensive growth was due, on the one hand, to the expansion of the workforce and, on the other hand, especially to the rising relative numbers of pensioners. Additionally, manyKVs increased per capita generosity, which led to intensive growth of expenditures.[32] Columns (4), (9) and (10) give an indication of the aggregate social significance of KVs compared to Bismarckian social insurance. While, in 1871, all Prussian KVs' insurants together amounted to 0.67 percent of the German population, they accounted for 2.17 percent in 1920. In contrast, the coverage of Bismarckian health and invalidity insurance was notably higher, starting with 9.7 percent in 1871 and reaching about 22 percent by 1920.

In order to assess the concentration phenomenon—the focus of this investigation—Table 5 depicts two pieces of information. On the one hand, it shows the development of the number of Prussian KVs over time. From 71 in 1861, the number of operating funds peaked in 1870/71 at 91. After that, the number then decreased by more than 50 percent, to 44 percent, in 1920. On the other hand, the table displays the arithmetic mean and the median of the

[28] Jopp, *The Welfare State Evolves* (cf. n. 29).
[29] Note that Bismarckian insurance introduced survivorship pensions as early as 1911.
[30] KV-level data show that the average widow's (orphan's) pensions predominantly amounted to 50 or 60 (10 or 15) percent of average invalidity pensions.
[31] Minor benefits such as funeral costs, educational support and others are omitted here.
[32] For replacement rates of pensions and sick pay, see Jopp, *The Welfare State Evolves* (cf. n. 29); Tobias A. Jopp, Old times, better times? German miners' Knappschaften, Pay-as-you-go Pensions, and Implicit Rates of Return, 1854-1913, forthcoming in: *Business History* (2011).

Table 4. Prussian Knappschaften from an aggregate perspective

Year	Knappschaft social insurance								Bismarckian social insurance	
	Contributors (in 1,000 persons)	Pensioners (in 1,000 persons)	Invalids in % of (2)	Knappschaft members in % of German population	Sick Pay (in 1,000 marks)	Health Care (in 1,000 marks)	Pensions (in 1,000 marks)	Invalidity pensions in % of (7)	Coverage of health insurance in % of German population	Coverage of disability insurance in % of German population
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1861	118.9	21.0	23.1	-	564	661	1,298	47.8	-	-
1866	159.3	29.7	22.0	-	763	907	1,927	48.5	-	-
1871	226.8	48.3	20.4	0,67 %	1,043	1,304	3,170	47.2	-	-
1876	260.9	67.3	23.2	0,76 %	1,727	1,839	6,317	51.5	-	-
1881	289.4	86.8	24.1	0,83 %	1,520	1,988	8,293	53.6	-	-
1886	328.7	110.1	25.3	0,93 %	2,667	2,529	11,288	54.1	9.7	-
1891	429.1	132.1	28.4	1,13 %	3,962	3,575	13,982	57.7	13.8	-
1896	469.1	153.8	31.4	1,18 %	5,012	3.956	17,350	60.4	15.1	22.0 (1897)
1901	636.7	156.3	39.0	1,39 %	10,681	6,299	23,147	61.7	17.0	-
1906	729.3	183.4	40.0	1,49 %	11,605	11,248	29,272	62.2	19.1	23.1
1911	683.9	206.8	40.3	1,36 %	17,026	17,244	37,428	69.0	20.8	24.3
1916	773.3	292.4	30.2	1,57 %	14,639	18,386	47,469	61.7	-	-
1920	1,013.9	327.6	27.8	2,17 %	126,376	155,758	57,725	56.2	-	-

Note: (1) includes established and unestablished miners. From 1908 onwards, contributors are those of the pension section. Column (2) includes invalids, widows and orphans.
For the year before 1876, one Prussian Thaler is converted into three marks.
Source: Own calculation based on Ministerium für Handel und Gewerbe, *Statistik* (see Table 2); Khoudour-Castéras, *Welfare State* (cf. n. 23), 234-236.

annual KV size distribution.[33] KV size itself is measured in terms of contributors because the number of contributors better reflects the true financing potential on which a KV could rely. It is straightforward to argue that the expansion of the mining workforce, which is tantamount to an expansion of the KVs' membership, and the net reduction in the number of KVs (absolute concentration) must have resulted in changes of the average KV size. Obviously, average KV size always exceeded median KV size and, moreover, grew much faster, which is indicative of a growing size disparity (relative concentration). The former amounted to 1,675 contributors in 1861, while the latter was 449. The growing difference between the two measures indicates clearly that the annual KV size distributions were extremely unequal; there were few large KVs, but a considerable number of small- and medium-sized ones.

Table 5. Number of Prussian Knappschaften and measures of Knappschaft size

	1861	1871	1881	1891	1901	1911	1920
Number of Knappschaften	71	91	83	74	73	65	44
Median Knappschaft size	449	566	667	1,049	941	1,039	5,999
Average Knappschaft size	1,675	2,492	3,487	5,878	8,722	10,523	23,044

Note: KV size is measured in terms of contributors. From 1908 on, contributors are those of the pension section.
Source: Ministerium für Handel und Gewerbe (1862-1922), *Statistik* (see Table 2).

The net reduction in the number of KVs resulted from a large number of mergers and liquidations in combination with a low number of entering KVs. In all, 20 mergers and 22 liquidations that took place between 1869 and 1917 are mentioned in the KV statistics. Regarding mergers, 37 KVs were absorbed by 13 other KVs. Of the 20 mergers, five formally created new funds, while the other 15 were real absorptions. While half of all liquidations occurred during World War I, absorptions took place during three phases: 1869-1877, 1885-1891 and 1907-1913. It is hard to say what could have made these periods so conducive to merger activity. However, they might actually reflect underlying mining-cycle fluctuations.[34]

To detail the picture of growth and concentration, Table 6 reports Hirschman-Herfindahl indices (HHI) of concentration on the level of mining administration regions and on aggregate. Indices reveal: (i) In the regions of Breslau, Clausthal and Dortmund, concentration was high from the start; (ii) In the latter two regions, concentration increased further

[33] Roland Eisen, Market Size and Concentration: Insurance and the European Internal Market 1992, in: *The Geneva Papers on Risk and Insurance* 16 (1991), 263-281, 270-271.

[34] We actually know from one of the type-B-mergers, conducted in 1890 in the Ruhr between the *Märkischer KV*, *Essen-Werden'scher KV* and the *Mülheimer KV*, that it was done as a direct response to the implementation of Bismarckian invalidity and old-age insurance in 1889 (in force as of 1891); see Ulrich Lauf, *Der Allgemeine Knappschaftsverein zu Bochum (1890-1923) – Mythos und Wirklichkeit*, Bochum 2009, 14-21.

over time; (iii) Intraregional concentration was lowest in Bonn and Halle, but both regions also saw an increasing degree of concentration; and (iv) On aggregate, concentration among Prussian KVs was modest at first and then continuously increased towards World War I.

The concentration process that obviously took place in Prussian *Knappschaft* insurance was driven by a combination of internal and external growth of KVs. Clearly, if the coal or ore fields, for which a KV was responsible, experienced long-term prosperity, the KV did, too. If local or regional resource deposits, however, came near economic or technical exhaustion, production stagnated, and so did the KV. This is simply because mine owners would have reacted by adjusting production capacities—capital such as steam or electrical engines, other technical equipment, shafts, and workforce—downwards. It was definitely the labor input that could be cut most rapidly to reduce costs. Maybe with a time lag, a KV would have seen a steady decline in memberships, for the most part due to young recruits staying away, but also due to labor turnover into other KV areas.

Table 6. Hirschman-Herfindahl indices of concentration

Year	OBAB Bonn	OBAB Breslau	OBAB Clausthal	OBAB Dortmund	OBAB Halle	Entire Prussia
1861	0.105	0.654	-	0.434	0.159	0.077
1871	0.090	0.592	0.430	0.453	0.164	0.079
1881	0.098	0.601	0.239	0.497	0.218	0.086
1891	0.116	0.645	0.483	0.937	0.206	0.161
1901	0.139	0.639	0.459	0.964	0.197	0.209
1911	0.153	0.625	0.474	0.970	0.271	0.239
1916	0.142	0.627	0.654	0.967	0.217	0.205
1920	0.163	0.635	0.412	0.969	0.256	0.209

Note: Measured are the respective shares of KVs in all contributors. OBAB abbreviates *Oberbergamtsbezirk*. A HHI of 1.0 indicates that there was only one KV. A HHI close to zero indicates high fragmentation.
Source: See Figure 1.

4. Mergers – a consequence of business policy or industry regulation?

According to the basic regulations of 1854 and 1865, the mining administration no longer ran KVs on the government's behalf. KVs were to form their own managing boards (*Knappschaftsvorstände*) instead. Those boards consisted of half miners' and firms' representatives, who decided upon all business matters and made merger and liquidation decisions.[35] Until the reform of the regulations in 1906, the new *Knappschaft* law, firms elected their representa-

[35] Part of each board also was a mining administration official representing the state, whose vote made the difference in case representatives had not found a majority for a decision alternative.

tives directly, while miners elected theirs indirectly via the election of so-called Elders (*Knappschaftsälteste*), respectable active or retired miners. The Elders, in turn, elected active miners or retirees from their own KV or another, or even mining officials, to advocate the insurants' interests in board meetings. The 1906 reform brought about a new, second self-management body, the general assembly (*Generalversammlung*), intended to monitor a KV's accounting framework and to replace the Elders as electors of the managing board.[36] Contemporary observers like Heinrich Imbusch or Ferdinand Bertrams expressed their worries about the firms having had the true power on the managing boards. They were concerned that the firms were making decisions according to their own interests, thanks to Elders, who often elected representatives more friendly to employers than to their official principals.[37] Lauf recently stressed that the mine owners or salaried managers had a clear intellectual advantage over Elders, which gave them 'opinion-leadership.'[38] Besides, employers could credibly threaten to fire uncooperative elder miners (as long as they were active, of course) or to influence their loyalty to their boss by giving them some kind of administrative tasks in the KVs (control the sick, for example).[39] As Geyer argues, in order to understand KV business policy and who profited most from decisions, it is crucial to know who really ruled the KVs.[40]

Based on the assumption that employers and employees indeed had different interests, the modes of social and economic interaction between miners, owner-managers or salaried managers, and the state as provider of the relevant regulatory framework, especially regarding conflict regulation, have attracted much scholarly attention.[41] The industrial relations historiography has one important implication for this paper: Conflicts of interest between miners and their employers existed about contractual issues, working conditions, safety issues and mine owners' paternalistic attitudes, and these conflicts deepened when miners increasingly formed organized opposition in trade unions. Therefore, these conflicts must also have been faced by

[36] Ulrich Lauf, Die deutschen Knappschaftsvereine (1854-1913). Ein altes Sozialsystem im Rückblick, in: *Der Anschnitt* 58 (2006), 264-294, 272-273.
[37] Heinrich Imbusch, *Das deutsche Knappschaftswesen,* Köln 1910, 63; Ferdinand Bertrams, Die Sicherstellung der Leistungen der preußischen Knappschaftsvereine durch das Knappschaftsgesetz vom 19. Juni 1906, in: *Glückauf* 48 (1912), 1411-1425, 1459-1471, 1499-1513, 1538-1554 and 1584-1597, 1413.
[38] Lauf, *Die deutschen Knappschaftsvereine* (cf. n. 37), 272.
[39] *Imbusch, Knappschaftswesen* (cf. n. 38), 63; Martin H. Geyer, The Miners' Insurance and the Development of the German Social State, in: *Sozialgeschichte des Bergbaus im 19. und 20. Jahrhundert*, ed. by Klaus Tenfelde, München 1992, 1046-1065, 1050.
[40] Geyer, *The Miners' Insurance* (cf. n. 40), 1046-1047.
[41] See, for example, Gerhard Adelmann, Die Beziehungen zwischen Arbeitgeber und Arbeitnehmer in der Ruhrindustrie vor 1914, in: *Jahrbücher für Nationalökonomie und Statistik* 175 (1963), 413-427; Klaus Tenfelde, *Sozialgeschichte der Bergarbeiterschaft an der Ruhr im 19. Jahrhundert*, Bonn-Bad Godesberg 1977; Bernd Weisbrod, Arbeitgeberpolitik und Arbeitsbeziehungen im Ruhrbergbau. Vom „Herr-im-Haus" zur Mitbestimmung, in: *Arbeiter, Unternehmer und Staat im Bergbau*, ed. by Gerald D. Feldman and Klaus Tenfelde, München 1989, 107-162.

the KV boards and must have influenced their decision-making process—at least to a certain extent.[42]

It is still unclear which role the different actors—the KV boards' members, the firms as the opinion leaders, the state as the regulator, and the external expertise of contemporary observers—played. It also remains unclear why one of the alternatives—(i) continuation of operation, (ii) merger or (iii) liquidation—was chosen in a particular period. This investigation explores whether economic, and especially actuarial, motives may be assumed. In general, the economic literature proposes a variety of motives to merge: to increase the market share, diversify risks, exploit economies of scale and scope, reach minimum efficient size, and to avoid insolvency.[43] On the one hand, as stated in the introduction, it may have been in the interest of a KV's management to view a merger as an insolvency alternative in case of financial distress. On the other hand, it might have been in the KV's interest to absorb another fund because there were opportunities to stabilize one's own growth and reduce one's own costs; and members of the absorbed KV might or might not have profited.

From the opinion in the literature that, in the end, it was the firms that dominated KV boards, it follows that business policy is very likely to reflect mine owners' interests. What *were* their interests? In my view, their main interest was, indeed, economic at its core—namely, being able to maintain a workforce as healthy, as satisfied and as productive as possible at the lowest possible cost. Several findings in my statistical analysis will be quite in line with this view. Since employers' contributions to KVs were a true cost item—and more so after implementing additional labor costs due to co-financing Bismarckian insurance—employers were arguably interested in keeping costs as moderate as possible. The point is that a KV entering into a state of financial difficulty for whatever reason—business-cycle fluctuations, structural decline, long-term demographic changes, or erratic expenditure shocks due to accidents—meant additional costs for firms. If, for example, the number of pensioners relative to contributors had risen, this inevitably would have required raising contributions, which firms also would have had to pay. Hence, it was in the economic interest of firms to operate a financially healthy KV. In fact, the contemporary discussion on actuarial deficiencies of KVs, which I summarize in the following subsection, gave the firms attractive arguments for how to improve a fund's financial soundness from an actuarial perspective.

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[42] Lauf, *Die deutschen Knappschaftsvereine* (cf. n. 37), 272.

[43] Ronald E. Shrieves/Donald L. Stevens, Bankruptcy avoidance as a motive for merger, in: *Journal of Financial and Quantitative Analysis* 14 (1979), 501-515; Michael C. Jensen, Takeovers: Their Causes and Consequences, in: *Journal of Economic Perspectives* 2 (1988), 21-48; Ran BarNiv/John Hathorn, The Merger or Insolvency Alternative in the Insurance Industry, in: *The Journal of Risk and Insurance* 64 (1997), 89-113.

4.1. Contemporary arguments in favor of mergers

During the nineteenth century, according to Borscheid, the financial innovation 'insurance' became more and more prevalent. Commercial voluntary insurance focused on life insurance, while compulsory social insurance addressed, in particular, the risks of sickness and invalidity.[44] Soon after 1854, when the 'era of social insurance' began for KVs, contemporaries started to discuss structural problems of those funds that were directly related to their role as insurance providers. This historical debate in the literature was, at its core, actuarial, and the main arguments were linked with the issue of KV size and the weaknesses of the pay-as-you-go method. Hence, focusing on the contemporary arguments in favor of mergers sheds some light on the available actuarial knowledge at the time.

Julius Hiltrop, for example, argued as early as 1869 that many KVs were, on the one hand, too small to ensure actuarial stability of their pension insurance scheme and, on the other hand, too large to successfully control for moral hazard in their health insurance scheme:

> Of greatest importance for a KV's usefulness and efficiency, however, is its size. The more members a KV has, . . . the more solid will it become in . . . granting benefits and overcoming challenges. . . . . The basic evil rather is the preposterous fusion of health and pension insurance; a KV's size too large for it provider of health insurance and too small for it provider of pension insurance.[45]

Others, like Albert Caron, Harry Karwehl, Heinrich Imbusch, and Ferdinand Bertrams, expressed similar thoughts; Karwehl, in particular, talked about high fragmentation—that is, the very unequal size distribution of KVs mentioned in the previous section—as the 'cancerous ulcer' of Knappschaft insurance.[46] Another contemporary, Peter Simons, suggested that larger KV areas, achievable by mergers, would result in a de-coupling of local, or even regional, economic growth or decline and a KV's financial state. This was because growing areas, where deposits were still rich, could cross-subsidize stagnating areas, where deposits were close to economic or technical exhaustion.[47] An industry regulator would very probably like this argument since it implies greater stability of the entire insurance scheme. Employers, as

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[44] Peter Borscheid, *Kurze Geschichte der Individual- und Sozialversicherung in Deutschland*, in: Versicherungsstatistik 1750-1985, ed. by Peter Borscheid and Anette Drees, St. Katahrinen 1988, 3-49.

[45] Julius Hiltrop, Über die Reorganisation der Knappschaftsvereine, mit Hinblick auf die Bildung von Versicherungsgenossenschaften für Arbeiter anderer Gewerbe, in: *Zeitschrift des königlich-preußischen statistischen Bureaus*, 9 (1869), 216-241, 225. This is my own translation of the German original.

[46] Albert Caron, *Die Reform des Knappschaftswesens und die allgemeine Arbeiterversicherung*, Berlin 1882, 20; Karwehl, Harry, *Die Entwicklung und Reform des deutschen Knappschaftswesens*, Jena 1907, 61-71; Imbusch, *Knappschaftswesen* (cf. n. 38), 61; Bertrams, *Sicherstellung* (cf. n. 38), 1413.

[47] Peter Simons, *Geschichte und Statistik der Wurm-Knappschaft in Bardenberg bei Aachen*, Berlin 1890, 11.

well as miners, in a prospering mining area would very probably not have liked to see their prosperity being redistributed to stagnating areas.

Obviously, contemporaries believed that running a pension-benefit scheme required a minimum efficient size that was larger compared to the minimum efficient size of health insurance; we may define it as the size beyond which there were no economies of scale left. The actuarial ideas behind this are well known in modern economics. With regard to moral hazard, for example, Guinnane and Streb tested the claim that in small KVs, where everybody knew and observed each other, the misuse of the fund's resources by claiming sick pay without being sick at all (called *Simulation* by contemporaries) could have been effectively prevented through social-sanction mechanisms.[48] Moreover, it is commonly agreed that insurers are exposed to a special sort of risk—the actuarial risk: Either each individual insured's effective claim or the aggregate effective claim of the insurants' collective, at the end of a period, will exceed (or fall short of) expected claims. Yet, economic theory suggests that the predictability of the number and, thus, the amount of claims improve with a growing collective of insurants. This is because an increase in the number of insurance contracts reduces the variance of the average individual claim towards zero via the (empirical) law of large numbers. Likewise, a decrease in size is equal to an increase in actuarial risk measured by the variance, and a small collective of insurants is generally associated with a higher variance. Hence, from a theoretical viewpoint, growth in contributors would have been good for KVs, and mergers were definitely a measure to jump immediately to a larger size level.[49]

Contemporaries like Caron or Karwehl, indeed, argued explicitly on the basis of the law of large numbers. Smaller KVs were said to be much more vulnerable than larger KVs to unpredictable events such as accidents or fluctuations in the number of contributors and pensioners. Thus, they had a higher ex ante variance of the average claim, which is equal to a larger bandwidth of possible positive or negative outcomes. Just as buying insurance reduces uncertainty about an individual's future income, expanding the collective of insurants reduces uncertainty about future states of finances on the side of the insurer himself. Caron also talked about a steady state (*Beharrungszustand*), in which all fundamental actuarial data—the inflow of new members per age group, the outflow of contributors due to death, turnover or invalidity, and the outflow of pensioners due to death, among others—remained unchanged over a

[48] Timothy W. Guinnane/Jochen Streb, Moral hazard in a mutual health-insurance system: German Knappschaften*, 1867-1914*, in: *Journal of Economic History* 71 (2011), pp. 70-104.

[49] See, for example, Peter Albrecht, Gesetze der großen Zahlen und Ausgleich im Kollektiv – Bemerkungen zu Grundlagen der Versicherungsproduktion, in: *Zeitschrift für die gesamte Versicherungswissenschaft* 71 (1982), 501-538. The law of large numbers in its empirical formulation says that the relative frequency of a particular event converges towards its true, but unknown, probability of occurrence, the more observations are included.

very long time period, so that perfect predictability of financial needs was achieved. This steady state, however, was claimed to require a large size and the law of large numbers coming into effect.[50]

As a consequence of actuarial considerations, mergers of small KVs into larger ones, or even mergers of all KVs into one fund for Prussia or Germany as a whole, were repeatedly demanded.[51] In particular, it was postulated to separate pension from sickness insurance in order to allow for different fund sizes in the quite distinct insurance sections. Caron, for example, claimed:

> Consequently, the first basic condition for a structural reform of *Knappschaft* insurance is to form sufficiently large *Knappschaft* areas so that the law of large numbers comes into effect. Thus it would be perfect to merge all Prussian KVs into one pension insurance fund.[52]

Karwehl furthermore stated:

> Further concentration is truly essential. Besides some other disadvantages for comrades arising from high fragmentation, small and smallest KVs are by far not able to accomplish their social tasks.[53]

Besides considering KV size as a major issue, contemporaries also discussed the usefulness of the pay-as-you-go (PAYGO) method, which KVs universally chose to finance expenditures. In a PAYGO system, current health and pension expenditures in a given period are financed by revenues of the currently employed. KVs probably chose the PAYGO method because it enabled them to immediately pay out pensions without relying on the accumulation of reserves for each miner or each generation (birth cohort). Contemporaries were definitely aware of the sensitivity of the PAYGO method to long-term demographic changes or sudden financial shocks. However, they seem not to have considered the method formally, as something that could be depicted as an equation, but intuitively knew that rising numbers of pensioners per contributor or rising numbers of sick days per contributor necessarily required adjustments of the contribution rate and the gross pension level. Jopp shows that those adjustments widely led to diminishing implicit rates of return over time, hence postponing financing burdens arising from the increasing number of pensioners. In particular, it was the large KVs in the growing mining areas that could keep implicit rates by and large constant over time.[54]

There is no evidence at all that contemporaries really thought about implicit rates of return. They did not even explicitly argue on the basis of the pensioners-to-contributors ratio's

[50] Caron, *Reform* (cf. n. 45), 8; Karwehl, *Entwicklung* (cf. n. 45), 61-62.
[51] Debates finally culminated in the foundation of the *Reichsknappschaft* in 1923.
[52] Caron, *Reform* (cf. n. 45), 20. This is my own translation of the German original.
[53] Karwehl, *Entwicklung* (cf. n. 45), 72.
[54] Jopp, *Old times, better time*s? (cf. n. 34).

(PCR) direct relation to the PAYGO equation. Table 4 has already given an indication of the rising burden with pensioners per contributor. In fact, the average PCR of the smallest-sized KVs up to 200 contributors was at least 50 pensioners per 100 contributors since 1873 and not below 22 between 1861 and 1872. For larger KVs, historical PCRs ranged between 12 and 26 in 1861 and 25 and 48 in 1920, hence nearly doubled, on average. However, contemporaries understood aging and what the unsustainability of pension finance could mean;[55] and they thought that the 'golden way' to sustainability—i.e., to a situation in which every generation of miners would be treated equally—was to increase size and was to sort out unviable KVs.

4.2. The industry regulators' intentions

The mining administration as the industry regulator most likely shared the view that increasing the KVs' size by mergers was a useful strategy. In fact, the regulations of 1854 and 1865 did not say much on this topic, merely that a KV should be neither too small nor too large.[56] Prior to the reform of Knappschaft law in 1906, however, the administration exerted some verbal pressure. Hilt, for example, informs us about an attempt in 1870, essentially initialized by mining official Hermann Brassert, to merge all KVs in the region of Bonn into one pension fund; this attempt failed because most firms opposed the proposal.[57]

Another attempt of the administration to clear its position regarding size and mergers was the ministerial decree of 1883, in which it reads:

> It has been repeatedly stated that the fusion of small KVs among themselves or with a larger fund is the appropriate way to ensure efficiency. . . . [58]

The administration concluded that, indeed, some mergers were done, but that they were by far insufficient. Yet, there is no evidence that, before 1906, the administration really forced mergers or liquidations upon KVs. There is only evidence that the verbal pressure increased.

The amending law of 1906, then, made it possible for the regulator to formally force mergers or closures upon KVs (§177a and b).[59] Bertrams informed us that the liquidation of

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[55] Karl Brämer, Der finanzielle Zustand der preußischen Knappschaftsvereine, in: *Zeitschrift des königlich-preußischen statistischen Bureaus* 20 (1880), 289-314. 314.

[56] Ministerium für Handel und Gewerbe, Instruction vom 3. April 1855, zur Ausführung des Gesetzes vom 10. April 1854, betreffend die Vereinigung der Berg-, Hütten- und Salinenarbeiter in Knappschaften, für den ganzen Umfang der Monarchie, in: *Zeitschrift für das Berg-, Hütten- und Salinenwesen in dem preussischen Staate* 3 (1856), 25-31.

[57] Hilt, Ueber die Errichtung einer allgemeinen Pensionskasse für die Knappschaftsmitglieder im Oberbergamtsbezirk Bonn, in: *Zeitschrift für das Berg-, Hütten- und Salinenwesen in den preussischen Staate* 25 (1877), 1-28.

[58] Ministerium für Handel und Gewerbe, Ministerial-Erlass vom 1. October 1883 an die sämmtlichen Königl. Oberbergämter, betreffend Aenderung der Statuten der Knappschaftskassen auf Grund des Reichsgesetzes vom 15. Juni 1883 über die Krankenversicherung der Arbeiter, in: *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im preussischen Staate* 31 (1883) 77-85.

the *St. Wendeler KV* in 1906, for example, was a consequence of this new regulatory instrument.[60] On the whole, evidence does not suggest that mergers were a consequence of regulatory policy, but a result of business policy. Yet it remains quite unclear whether KVs that absorbed another one did so to help the absorbed KV out of an actuarial trap or to seek one's own growth opportunities, or to appeal to the regulator.

5. Merge or fail? An empirical model of mergers among *Knappschaften*

The previous section shed some light on the contemporaries' and the state's general position: that a larger size is better than a smaller size, and that small KVs are to be merged into others. Mine owners and the administrative staff, as providers of the general intellectual input for KV management, could definitely have had some actuarial knowledge. In order to extend the qualitative analysis on mergers quantitatively, a statistical model based on survival analysis will be presented in the following section. This model uses a set of explanatory variables on the KV-level to examine the probability with which a KV was either absorbed or liquidated, respectively, given that it had reached different points in time; see the Appendix for a brief description of the model.

5.1. Determinants of mergers and liquidations with explanatory potential

In the following, I briefly summarize the set of variables applied. Making a clear distinction between mergers and liquidations is important since the two modes of exit are not likely to be affected by covariates in the same way. Moreover, as was argued above, one basic business-related decision at any point in time was to decide whether to continue operation or to exit by merger or liquidation. By considering both modes of exit explicitly, this model goes beyond usual firm-survival models that merely consider exit per se as event.[61]

The aforementioned discussion of contemporaries' views centered on the claim that KV size matters and that many KVs had still not reached the appropriate size; merging funds was proposed as an effective measure to increase their size and to improve the actuarial underpinnings of small KVs. In this context, KV size is hypothesized to play a major role in explaining exit decisions. As shown above, the annual size distributions were extremely unequal, and many KVs were arguably too small to operate on a sound actuarial basis. In order to measure the importance of that consideration, I incorporate several controls with respect to

[59] Otto Steinbrinck, *Gesetz vom 19. Juni, betreffend die Abänderung des Siebenten Titels im Allgemeinen Berggesetze für die preußischen Staaten 24. Juni 1865*, *nebst Kommentar*, Berlin 1908, 152-158.
[60] Bertrams, *Sicherstellung* (cf. n. 38), 1553.
[61] Miguel C. Manjón-Antolín/Josep-Maria Arauzo-Carod, Firm survival: methods and evidence, *Empirica* 35 (2008), 1-24.

size in the model. First, current KV size is measured by the sum of contributors. Second, start-up size—the size of a KV in its first year, for which an observation is available—is also included. Another time-invariant variable is the geometrically averaged mean growth rate of KV size over a KV's entire life cycle; we can call this variable the average biological interest rate of the KVs' PAYGO schemes.[62] It measures the long-term growth pattern and, thereby, gives an indication of structural change regarding the mining areas underlying the KVs' insurance. A negative average growth rate implies, by tendency, long-term shrinkage and, correspondingly, a positive-one long-term prosperity.

Furthermore, I employ several measures of financial distress according to the 'rescue hypothesis.' First, the invalids-to-contributors ratio (ICR) and the survivors-to-contributors ratio (SCR) measure the current burden with invalidity pensioners and with widows and orphans; these are the components of the pensioners-to-contributors ratio already introduced. The burden from pensioners increased for many KVs, especially for the comparatively smaller ones and those subjected to long-term structural decline. Besides, inclusion of those ratios follows directly from the functioning of the pay-as-you-go mechanism, which the KVs applied.[63] Depending on the development of wages—hence productivity—the additional financing burden on contributors might, in the end, reduce disposable income and lifetime implicit rates of return. Second, the start-up ICR and the start-up SCR measure the initial burden from pensioners. In order to allow the effect of start-up size to vary with the initial burden from pensioners, I incorporate interactions of start-up size with the respective ratios. Third, analogous to the ICR and SCR, the sick-days-to-contributors ratio measures the financing burden on contributors that arose from the sickness insurance section. The more sick days the average contributor had to finance—caused by incentives for malingering, for example[64]—the greater the financial pressure on a KV.

A few more variables are incorporated in the model to capture part of the heterogeneity among KVs. One variable is the share of established contributors among all contributors.

[62] Robert K. Frhr. von Weizsäcker, Politökonomische Aspekte der Rentenversicherung und Bildungsfinanzierung im Lichte des demographischen Wandels, in: *Das demographische Problem als Gefahr für Rechtskultur und Wirtschaft*, ed. by Corinne Michaela Flick, München und Frankfurt am Main 2010, 155.

[63] Winfried Schmähl, Umlagefinanzierte Rentenversicherung in Deutschland – Optionen und Konzepte sowie politische Entscheidungen als Einstieg in einen grundlegenden Transformationsprozeß, in: *Soziale Sicherungssysteme und demographische Herausforderungen*, ed. by Winfried Schmähl and Volker Ulrich, Tübingen 2001, 123-204, 149-150. By definition, an increase in the number of pensioners per contributor—other things remaining equal—inevitably triggers adjustments according to the pay-as-you-go equation; the contribution rate could be raised in the following, the gross pension level could be lowered, the degree of subsidization from the outside (i.e., by drawing on the government or by drawing on one's own financial reserves accumulated in the past) could be increased, or the legal retirement age could be raised.

[64] Guinnane/Streb, *Moral hazard* (cf. n. 49); Lars Bluma/Stefan Schulz/Jochen Streb, Prinzipal-Agenten-Probleme in der knappschaftlichen Krankenversicherung: Die Bekämpfung des „Simulantentums" durch Anreize und Kontrolle, in: *Vierteljahrschrift für Sozial- und Wirtschaftgeschichte* (2010), 97, 310-334.

Established contributors were, in general, more costly than unestablished ones in that they often received higher benefits given equal contribution payments. Against the background of an increasing ICR or SCR, a decreasing share of established miners may release the KV from some financial pressure. Indeed, it may also indicate structural problems since ever fewer miners obviously had applied for established status, hence had not decided to enter into a long-term relationship with the KV. Following Guinnane and Streb, the firms' share in costs is included as well.[65] Furthermore, the young-to-old ratio equals the ratio between established contributors aged 16 to 35 and those aged 36 and older. This is a proxy measure for a KV's age structure. A continuously diminishing ratio can be interpreted as a hint at structural aging of the contributor base. Indeed, data from the KV statistics show that this ratio varied notably across KVs.

The diversification of a KV's membership across the different mining subsectors is measured by a Hirschman-Herfindahl index (HHI) using subsector shares for each KV (e.g., the number of insurants employed in hard-coal mining divided by the number of all insurants; see Table 1). If a KV insured miners who were employed in only one subsector, the HHI equals one. If insurants were equally distributed over all subsectors, the HHI equals 0.083. Hence, the closer the HHI is to the latter quantity, the less concentrated are a KV's insurants in only one subsector. Contemporaries such as Harry Karwehl believed that the various subsectors reflected different degrees of occupational hazard, with hard-coal mining being the most hazardous activity.[66] A mixture of hazards might have been of actuarial advantage and might, presumably, have lowered dependency on the economic fate of only one subsector. In addition, I incorporate a variable intended to measure the potential of correlated risks. As mentioned above, mining was an economic activity with a high risk of massive accidents involving many insurants at the same time and, thereby, overwhelming a KV with many immediate sickness or invalidity claims. Clearly, mass accidents destroy the stochastic foundation of insurance because the risk that one miner claims sickness or invalidity is not independent of the risk that another miner had claimed so before; this is because both individual risks share the same origin (the accident).[67] I measure the potential for correlated risks on the KV level by dividing the average number of contributors per mine by all contributors. If a KV was responsible for exactly one mine, the ratio equals one, expressing that all miners could have been affected by an accident at the same time. The more mines a KV was responsible for, the

[65] Guinnane/Streb, *Moral hazard* (cf. n. 49).
[66] Karwehl, *Entwicklung* (cf. n. 45), 74.
[67] From the perspective of an insurer, the risks that individuals sharing the same occupation make their claims seem, in general, to be correlated simply because the occupation brings about the same accident risks and diseases for everyone.

smaller was the ratio and, hence, the lower was the potential for immediate financial disaster from correlated risks.

Finally, I include a variable that measures the business cycle to which KVs were subjected. The business cycle is measured in terms of the deviation of hard coal, brown coal, iron ore, zinc ore, lead ore or copper ore mined from trend production. Therefore, the trends of those production series between 1861 and 1920 have been estimated on the level of mining administration regions (the *Oberbergamtsbezirke*).[68] To each KV, I ascribe the trend deviation of the single most important product. I assume that steelworks were subjected to the regional iron- ore trend and that salt works and stone pits were subjected to the hard-coal trend (Dortmund) as well as the iron-ore trend (Bonn and Halle).

Finally, explanatory variables were checked for multicollinearity by evaluating the pair-wise correlation coefficients across them.[69] As expected, there is a high correlation beyond 0.75 between the ICR and SCR, and the SCR and the sick-days-to-contributors ratio. However, all variables measure different aspects and are, therefore, kept in the regressions.

5.2. Results

Table 7 contains the estimation results and helps to explain, from a statistical point of view, why KVs might have merged. For reasons of convention, I focus on the statistically significant coefficients, those in bold print. The regression model is formulated from the perspective of the KVs that were absorbed or liquidated. This means that the model sheds light on target characteristics and on how these affected the likelihood of being absorbed or liquidated. It is important to note that the model does not focus directly on the characteristics of the absorbing KV. However, it is possible to draw conclusions about the motives of the absorbing KV by linking target characteristics with the aforementioned interests of firms as the dominant actor.

As argued above, KV size played a major role in the contemporary discussion, especially as it motivated merger activity. Therefore, we expect to find size to be essential in explaining absorptions. In fact, current size does not play as essential a role as the insignificance of coefficient (10) implies. From a statistical viewpoint, there is no evidence that the size of the target KV was decisive. In particular, there is no evidence that absorption was a measure intended to systematically help smaller KVs out of their actuarial trap or a measure to systematically improve the absorbing KV's actuarial position. This conclusion is supported by the finding that, in contrast, current size does explain liquidations: The model says that the small-

[68] In almost all cases, a linear or quadratic trend yielded a reasonable fit.
[69] Charles H. Feinstein/Mark Thomas, *Making history count – a primer in quantitative methods for historians*, Cambridge et al. 2002, p. 323.

er the current size was, the more likely a KV was to end up in liquidation than in absorption. Although contemporaries perceived a small KV size as an actuarial disadvantage that could—and should!—be solved by mergers of those small funds among themselves or with larger KVs, the statistical model implies that KVs had, on average, not acted according to this behavioral norm. Hence, KVs did not feel that solidarity with their fellow funds; members of a prospering larger fund probably did not want to share their prosperity with members of a distressed fund.

Although current size does not explain mergers, conditions at the start, in 1861, did, indeed, matter. Start-up size has explanatory power in both models. Regarding absorptions, the model says that KVs that began with a high invalids-to-contributors-ratio and a small size—coefficient (4)—were more likely to be absorbed at any point in time than KVs with the same initial burden with invalids, but a higher KV size.[70] This finding has two implications: First, starting positions predetermined, to some extent, the funds' future survival process. Second, the finding supports the 'rescue hypothesis.' Regarding liquidations, the effect of start-up size is significantly positive.

Let us focus now on the financial distress variables, the ICR and SCR. While the current ICR does not help to explain absorptions—in particular, not in the presence of the alternative 'liquidation'—the current SCR does. The positive sign of coefficient (8) implies that the higher the current burden with survivors was, the more likely a KV was to become a target for absorption. This finding also makes the case for rescue mergers that were motivated, in part, by the desire to protect survivors, who would have lost income in the case of liquidation. Yet this finding does not explain why invalids were not statistically relevant for absorbing another KV. In the case that all potential targets were burdened to some extent with pensioners, it is possible that KVs targeted those with a less-costly survivor burden. Regarding the competing risk 'liquidation,' both the ICR and SCR as main financial distress variables have no significant explanatory power.

Another important variable—not the least because of the coefficients' magnitude in both cases—is the young-to-old ratio, which measures a KV's age structure. Indirectly, it measures the growth opportunities embedded in the respective mining area and, thus, how attractive it was for young people to enter the mining sector as new employees. With respect to absorptions, coefficient (11) implies that the likelihood of becoming a target for merger by absorption increased notably if the young-to-old ratio was high. This is consistent with the

[70] From a technical point of view, incorporating an interaction with the initial burden with invalids has the consequence that the effect of start-up size itself is evaluated at a value of zero of the interacted variable, and not at its mean. Accordingly, a significant interaction implies a modification of the coefficient.

idea that a KV, interested in improving its own financial position by absorption, absorbed another fund only if it was really attractive. A relatively high number of young relative to old contributors must have been appealing to a KV, especially to the mine owners, because this is a signal of prosperity. If KV board members, including miners' and mine owners' representatives, were to ensure the future of their own fund, they had to ensure a steady future inflow of young insurants. This was definitely in the interest of mine owners, who wanted to seek opportunities to keep costs low and to avoid dealing with 'wounded' KVs. This view is supported by the finding on liquidations. If the ratio got worse and, hence, the number of young miners declined relative to the number of old ones, KVs were liquidated. That is to say, KVs that were obviously suffering from structural decline of the mining industry in their area were not attractive targets. This fact itself is straightforward. However, if the actors on the absorbing KVs' boards were of the same opinion as the contemporaries—namely that KVs in trouble were to be rescued—they did not draw the same conclusion, which was to perform corresponding rescue absorptions. The growth pattern variable, coefficient (6), points in the same direction.

The financing share of the firms, coefficient (13), implies that the higher the share was, the more likely a KV was to become a target of absorption. Board members of the absorbing KV, especially the mine owners, might have interpreted a rise in that cost share in one of two ways: On the one hand, they might have found that it also signaled prosperity in the respective 'targeted' mining area, which allowed the mine owners there to unburden insurants out of additional profits. Thus, it might have been attractive to incorporate those employers in one's own KV since they were obviously willing to contribute—or, at least, they were used to contributing—more. On the other hand, there is room to speculate about an alternative interpretation. A rise in the entrepreneurs' cost share could have also signaled growing financial distress, hence the opposite. Given that contributors were already sufficiently burdened with the financing of costs, entrepreneurs were under pressure to inject additional resources in order to prevent the KV from being underfunded. Accordingly, the absorption would not have been done because of an advantage for the absorbing KV, but would have been more of an insolvency-avoidance merger. I tend to interpret the coefficient as implying growth potential.

Finally, and not surprising, KVs were also more likely to be absorbed if they were diversified over at least two mining subsectors. This finding also supports the 'self-interest' hypothesis. However, contrary to my expectation, a decreasing potential for correlation of individual risks—which is not an actuarial disadvantage at all—drove the probability of liquidation up, not down. This observation is somewhat counter-intuitive. One of the following

Table 7. Determinants of merges and liquidations in a competing risk model

Dependent variable in all models: log hazard rate			
Variable	**Description**	**Absorption**	**Closure**
Time-invariant variables			
(1) Start-up size	Number of a fund's contributors in first observed year	0.00003 (0.00008)	**0.00049**** (0.00022)
(2) Start-up invalids-to-contributors ratio	Number of invalids per 100 contributors in first observed year	0.05718 (0.06314)	-0.18035 (0.21767)
(3) Start-up survivors-to-contributors ratio	Number of survivors per 100 contributors in first observed year	-0.01478 (0.02775)	0.07451 (0.07822)
(4) Start-up size * Start-up invalids-to-contributors Ratio	Interaction term	**-0.00003*** (0.00001)	0.00001 (0.00009)
(5) Start-up size * Start-up survivors-to-contributors Ratio	Interaction term	6.06e-06 (7.09e-06)	-0.00008 (0.00007)
(6) Growth pattern	Average geometric growth rate of size	-0.01335 (0.08612)	**-0.16845**** (0.08803)
Time-varying variables			
(7) Invalids-to-contributors ratio	Number of invalids per 100 contributors per year	-0.00009 (0.00044)	-0.00064 (0.00087)
(8) Survivors-to-contributors ratio	Number of survivors per 100 contributors per year	**0.00024***** (0.00008)	-0.00002 (0.00020)
(9) Invalids-to-contributors ratio * Survivors-to-contributors ratio	Interaction term	3.72e-08 (9.02e-08)	-3.59e-07 (3.17e-06)
(10) Size	Number of contributors per year	-1.67e-07 (3.03e-07)	**-0.00001**** (4.69e-06)
(11) Young-to-old ratio	Number of established contributors aged 16 to 35 to those aged 36 and more per year	**0.07359**** (0.03667)	**-0.06852*** (0.03980)

Table 7. Continued.

Dependent variable in all models: log hazard rate			
Variable	**Description**	**Absorption**	**Closure**
(12) Established contributors	Share of established contributors in all contributors per year	-0.03008 (0.02965)	0.05947 (0.04674)
(13) Firm's cost share	Ratio of employers' contributions to total costs per year	**0.05567**** (0.02258)	0.07724 (0.04718)
(14) Sick days-to-contributors ratio	Number of paid sick days per contributor per year	-0.00031 (0.00078)	0.00032 (0.00069)
(15) Diversification 2	Herfindahl index with respect to subsector employment shares per year ($0.9 \leq HHI < 1.0$)	**0.03970*** (0.02332)	-0.03889 (0.02668)
(16) Diversification 3	Herfindahl index with respect to subsector employment shares per year ($0.7 \leq HHI < 0.9$)	**0.03707**** (0.01887)	0.00479 (0.01485)
(17) Diversification 4	Herfindahl index with respect to subsector employment shares per year ($HHI < 0.7$)	**0.03808*** (0.02030)	-0.03996 (0.02726)
(18) Correlated risks	Average number of contributors per mine divided by all contributors	-0.01694 (0.02350)	**-0.03839***** (0.01230)
(19) Mining cycle	Deviation from production trend as percentage of trend	-0.01246 (0.02509)	-0.01204 (0.04744)
Number of observations		4,439	4,439
Log-pseudolikelihood		-133.93	-72.15
Wald χ^2		111.34	126.50
Prob > χ^2		0.00	0.00

Note: Displayed are coefficients, not hazard ratios. Standard errors in brackets are robust. For ties, the Breslow method is used. ***, ** and * denote statistical significance on the one, five and ten per cent levels. Diversification 1 (HHI=1) is reference and therefore omitted.

explanations may apply: First, decision makers were simply not aware of those actuarial relationships, so they were not relevant to the decision. Second, such an actuarial advantage is worth nothing if a KV faced structural or actuarial problems. Hence, if, in practice, the potential for correlation of risks might have decreased, this alone was not helpful.

6. Conclusion

This paper deals with the occupational social insurance funds of Prussian miners and asks what might have motivated actors to enter into a long-term concentration process driven, to a large extent, by external growth. From the perspective of absorbed and, for comparative reasons, of liquidated *Knappschaften*, the determinants of mergers and liquidations between 1861 and 1920 are explored, particularly by use of statistical inference. In the current state, the regression model is intended to test indirectly for hypotheses on economic motivations.

Part of the findings supports the baseline hypothesis that mergers were a rescue measure. KVs could have entered a state of financial distress right from the start of the insurance system in the middle of the 1850s or over the course of the subsequent years. Contemporaries linked financial distress of KVs with matters of size and the weakness of the PAYGO mechanism. Consequently, a solution to these problems, perceived to be of crucial importance for the long-term prospects of *Knappschaft* insurance, was commonly seen in mergers.

In addition, findings suggest even more strongly that the targets, absorbed by other KVs, must have been quite attractive ones. Having been in a state of financial distress was definitely not an attractive target characteristic. First, the higher both the ratio of young established contributors to old contributors and the entrepreneurs' financing share in total claims costs were, the more likely it is that a KV was absorbed; the effects were much higher than those supporting the 'rescue' hypothesis. Second, the more diversified a KV was over mining subsectors, the higher was the hazard of absorption.

Beyond that, the additional statistical evidence on liquidations does support the 'self-interest' hypothesis, too. In the presence of the alternative, 'being merged into another KV,' KVs exhibiting a bad age structure—indicating recruitment problems—and a smaller or a diminishing size were liquidated. This implies that those KVs were not attractive enough to be rescued by absorption. Hence, the concentration process of the Prussian miners' social insurance funds was, indeed, a selection process of sorting out unsound funds, but not a process driven by acts of solidarity.

7. Appendix: The econometric model

This investigation studies time-to-event data from the Prussian KVs. The nature of the data makes the application of duration analysis possible. Precisely, I use a competing risk model based on Fine and Gray's (1999) approach. Their modification of Cox's (1972) proportional hazard model allows for correlation between the two modes of exit appearing, namely merger by absorption and liquidation.[71] Correlation could mean that the event 'liquidation' either prevented the event 'merger' from happening since it had happened first or that its presence as exit alternative had at least altered the probability of occurrence of merger ex ante.

Let T denote the time elapsed until a KV was merged into another fund or liquidated. A competing risk model assumes a joint distribution of survival times T_{merger} and $T_{liquidation}$. Hence, Fine and Gray's model allows for the influence of explanatory variables on both subdistributions of the joint distribution.

I evaluate the determinants of mergers and liquidations according to the following regression equation,

$$h_j[t; X(t)] = h_{0j}(t) * \exp[X(t)'\beta_j], \tag{1}$$

where j = 1 and j = 2 indicate the events 'merger' and 'liquidation', h_j denotes the exit mode-specific hazard rate, and t denotes observed years. The hazard rate depends on time as well as especially on set of time-varying explanatory variables, X(t). Because of the semi-parametric nature of the model, the respective baseline hazard, $h_{0j}(t)$, remains unspecified.

The subdistribution for event j is also called the cumulative incidence function. Regarding the two exit modes, Fine and Gray's proportional subhazards model might be alternatively written as

$$h_j[t; X(t)] = \lim_{\Delta t \to \infty} \frac{\Pr[t \le T < t + \Delta t, C = 1 | (T > t \text{ or } (T \le t \text{ and } C \ne 1)), X(t)]}{\Delta t}. \tag{2}$$

The estimated model is an exponential one. This means that a coefficient has to be interpreted as a semi-elasticity indicating by how many percent the log hazard rate changes if the explanatory variable changes by one unit.

[71] David R. Cox, Regression Models and Life-Tables, *Journal of the Royal Statistical Society* B 34 (1972), 187-220; Jason P. Fine/Robert J. Gray, A proportional Hazards Model for the Subdistribution of a Competing Risk, in: *Journal of the American Statistical Association* 94 (1999), 496-509.