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ECONOMIC PAPERS

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Jochen Streb

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RWI

#163

Imprint

Ruhr Economic Papers

Published by

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Joachim Schmidt
RWI, Phone: +49 (0) 201/81 49-292, e-mail: joachim.schmidt@rwi-essen.de

Ruhr Economic Papers #163

Responsible Editor: Christoph M. Schmidt

ISSN 1864-4872 (online) – ISBN 978-3-86788-182-1

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Bibliografische Informationen der Deutschen Nationalbibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über: *http//dnb.ddb.de* abrufbar.

ISSN 1864-4872 (online)
ISBN 978-3-86788-182-1

Timothy W. Guinnane and Jochen Streb[1]

Moral Hazard in a Mutual Health-Insurance System: German *Knappschaften*, 1867–1914

Abstract

The Knappschaft *underlies Bismarck's sickness and accident insurance legislation (1883 and 1884), which in turn forms the basis of the German social-insurance system today and, indirectly, many social-insurance systems around the world. The* Knappschaften *were formed in the medieval period to provide sickness, accident, and death benefits for miners. By the mid-nineteenth century, participation in the* Knappschaft *was compulsory for workers in mines and related occupations, and the range and generosity of benefits had expanded considerably. Each* Knappschaft *was locally controlled and self-funded, and their admirers saw in them the ability to use local knowledge and good incentives to deliver benefits at low cost. This paper focuses on a problem central to any insurance system, and one that plagued the* Knappschaften *as they grew larger in the later nineteenth century: the problem of moral hazard. Replacement pay for sick miners made it attractive, on the margin, for miners to invent or exaggerate conditions that made it impossible for them to work. Here we outline the moral hazard problem the* Knappschaften *faced as well as the internal mechanisms they devised to control it. We then use econometric models to demonstrate that those mechanisms were at best imperfect.*

JEL Classification: N33, N43, H55, H53, I18

Keywords: Sickness insurance; moral hazard; malingering; Knappschaft; social insurance

January 2010

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1 *Timothy W. Guinnane, Yale University; Jochen Streb, University of Hohenheim.* *– This is a slightly revised version of a paper that first appeared as Yale Economic Growth Center Discussion Paper No. 978. This paper is part of a larger project entitled "Vergangenheit und Zukunft sozialer Sicherungssysteme am Beispiel der Bundesknappschaften und ihrer Nachfolger," which was funded by the Leibniz-Gemeinschaft. We thank Virginia Calkins and Tobias Jopp for excellent research assistance. Jopp is also part of the larger project; see Jopp (2009). Herb Emery, James Fenske, Manuel Frondel, Amanda Kowolski, Carolyn Moehling, John Murray, Christoph M. Schmidt, and Ebonya Washington provided excellent suggestions on an earlier version of the paper. We also appreciate comments from seminar participants at the Rheinisch-Westfälisches Institut für Wirtschaftsforschung e.V. (RWI). We thank RWI for Nolan Ritter's research assistance, for additional funding, and for making our participation in this project possible. Our views are not necessarily those of RWI.* *– All correspondence to Jochen Streb, Department of Economics, University of Hohenheim (570a), 70593 Stuttgart, Germany, e-mail: j-streb@uni-hohenheim.de.*

1. Introduction

Most wealthy countries today face serious problems related to the way they insure their populations against the financial consequences of illness, accident, and old age. A central issue in the design of these social insurance schemes dogged them in the nineteenth century and remains critical today: how to target benefits to the program's intended beneficiaries. Many of the conditions or events against which policy intends to insure individuals are difficult or costly for others to observe. Without proper controls, generous benefits will both increase the welfare of the targeted population, as intended, and encourage others to claim they belong to the targeted population, wasting resources and perhaps reducing political support for the program. This paper focuses on a particular type of moral hazard that became a serious issue for sickness funds in the late nineteenth century: the role of replacement pay for sick workers in elevating absenteeism. Few people experience direct utility from medical treatment for imagined illness. But many observers thought that replacement pay for some workers gave them an incentive to feign or exaggerate maladies.[1]

Moral hazard of this form became an important question in the design and build-up of sickness and accident insurance system created in Germany in the late nineteenth century. This paper focuses on the *Knappschaften (*or KV*)*, the organizations through which German miners insure themselves against accident, illness, and old-age.[2] The *Knappschaften* predated Bismarck's famous social-insurance system and in many ways were the model for his system. The *Knappschaften's* problems implied serious difficulties in extending the system to other classes of workers; miners had long identified themselves as a privileged group with their own ideas of honor and self-help, and if moral hazard undermined mutual insurance in this industry then the entire idea was problematic. Germany's social-insurance system operating today is based, indirectly, on the model pioneered by the *Knappschaften*. These organizations still exist, and although the industries in which they work have been in decline, a single all-German *Knappschaft* (called *Knappschaft Bahn See*) open to all workers is still active. The *Knappschaften* had two distinctive features. First, the workers and firms in covered industries fund and run the organization themselves. Although they operate within constraints set down by the government, the *Knappschaften* tell us much about member preferences. Second, membership in the relevant *Knappschaft* was compulsory for anyone who worked in the covered industries. Adverse selection plagued contemporary, voluntary self-insurance schemes. The *Knappschaften* allow us to study health insurance in a context where adverse selection is not possible.[3]

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[1] A contemporary literature on another form of *ex ante* moral hazard in medical insurance notes that insurance may make individuals less likely to care for their health or safety. For a recent contribution see Dave and Kaestner (2009).

[2] *Knappschaft* is singular*, Knappschaften,* plural. The German literature usually refers to these institutions as *Knappschaftsverein*, or "*Knappschaft* organization" (KV). We refer to the *Knappschaft*'s members as "miners" as short-hand. The Knappschaften had two distinct roles: they provided sickness and accident insurance as well as disability insurance for cases where the workers were no long able to work, and benefits to survivors. This paper focuses on the sickness and accident insurance alone. The disability component is the subject of a future paper. For simplicity we refer throughout to "sickness" when we mean "sickness and accidents."

[3] Since all workers must join their *Knappschaft*, the only adverse selection possible would be that associated with choice of occupation. Clearly the *Knappschaft* made mining and the other dangerous occupations more attractive than they would have been in the absence of the *Knappschaft*. It is theoretically possible, as well, that men would decide to become miners because for some reason they thought themselves more likely to become ill. We have never seen a suggestion to this effect in the literature. It seems unlikely; before a worker could become a full member of the *Knappschaft*, a doctor had to certify that the worker was healthy (provide a *Gesundheitsattest*).

We focus here on a period of dramatic change, from the 1850s until World War I. The *Knappschaften* in this period faced an important question: how to transform often small, informal organizations into institutions that could meet the growing needs of their members, without destroying the sense of solidarity that allowed the *Knappschaften* to provide a guaranteed safety net without being overwhelmed by moral hazard problems. Moral hazard was a serious issue in the eyes of contemporary observers; Schlockow (1881, p. 126) is just one observer who viewed moral hazard as a serious threat to the entire mutual-insurance approach. *Simulation* (feigning illness) and *Verschleppung* (pretending to be ill after cured) supposedly plagued nearly all *Knappschaften.* The mean number of reported sick days per member per *Knappschaft* per year rose from 6.2 in 1867 to 9.7 in 1907, an average annual rate of increase of about one per cent per year.

This paper uses the official reports of the KV to test for the existence and extent of moral hazard. Contemporaries stressed an important trade-off that we study below. Larger *Knappschaften* were arguably better, *ceteris paribus*, than small. A larger institution could spread administrative overheads over more workers; could build and operate its own hospitals, with staff and facilities specialized for the problems facing their members; and a larger institution could better absorb the risk of unusual financial demands posed by a serious accident or outbreak of illness. Yet many claimed that the problem of moral hazard was worse in the larger *Knappschaften*. In a larger institution, workers were less likely to know each other personally and more likely to feel that in abusing the fund they are abusing an institution, rather than their friends' pocketbooks. A larger *Knappschaft's* members were typically also more geographically separated, because its mines and other works were spread out over a larger area. Such workers might be better able (or feel more emboldened) to make false reports to the organization.

2. An overview of the *Knappschaften*

The first *Knappschaften* date to the Middle Ages. Their role was clarified and strengthened by the *Joachimsthaler Bergordnung* (mining law) of 1584. The early *Knappschaften* focused on religious observance, and on representing the miner's interests before territorial lords. Their social-welfare functions developed in stages. Miners first collected voluntary contributions, following an accident, to support the injured miner or his widow and children. Later miners collected regular but still voluntary contributions to create a fund to pay for the consequences of accidents. The *Knappschaft* eventually adopted regular, obligatory contributions to this fund (the so-called "*Büchsenpfennig*"). But there was still no legal right to support from the fund; the KV remained a charitable organization rather than an insurance institution. In the final step the law regulated both the mandatory contributions and the miner's rights to compensation from the institution's fund. This change marked the *Knappschaft*'s transformation into institution for insurance in the modern sense. The *Knappschaften's* history reflects changes in the organization and control of mining itself. An important step came in the 1760s, when Frederick the Great's regime introduced the control principle ("*Direktionsprinzip*") for his Prussian territories. Under this system, both the mines and the *Knappschaften* were run by state employees. Mine owners had only an advisory role, and their rights were restricted to selling the mines' output.[4] Prussia dramatically

[4] This principle was introduced through many laws and edicts, reflecting the territorial fragmentation of Frederick's realm. The most important of which were the „revidierte cleve-märkische Bergordnung für das Herzogtum Cleve, Fürstentum Moers und für die Grafschaft Marck vom 29. April 1766;" the „revidierte schlesische Bergordnung vom 5. Juni 1769;" the „revidierte Magdeburg-Halberstädtische Bergordnung vom 7. Dezember 1772;" the „General-Privilegium für die Bergleute im Herzogtum Cleve, Fürstentum Moers und Grafschaft Marck vom 16. Mai 1767;

changed its mining law and administration in the 1850s. Owners obtained full control over their mines, along with the right to set wages, to hire and fire workers, etc.[5] Each *Knappschaft* now decided on contributions as well as benefits for members. In 1854 the method for computing workers' contributions was changed. A KV either required each member to pay a flat percentage of his wages, or could establish a set of classes, each with a fixed annual contribution. The new regulations required that sick pay be paid as a fixed amount and for a total of eight weeks only. Mine owners had to contribute an amount equal to at least half of the members' contributions (this condition was restated as §175 of the 1865 Act). Changes to liability law in 1871 gave owners compensation for their contributions to the *Knappschaften*; in case of liability for the injury or death of their workers, the KV's *entire* contribution to the worker or his heirs were subtracted from the firm's portion of any damages.[6]

The 1865 *Allgemeine Berggesetz* (general mining law) introduced an option intended to improve the *Knappschaft*'s ability to control costs. A *Knappschaft* could establish multiple funds for sickness and accident insurance while keeping a common pension fund for the membership as a whole. This new wrinkle reflected concern over *Simulation*. A pension fund needs a wide area to diversify risks, the argument went, but a sickness fund benefits relatively more from the ability to control costs. The new rule reflected serious moral-hazard problems with *Simulation* in the Ruhr area especially: "This rule was the consequence of frequent malingering, which in the Ruhr area led to a great increase in costs." (Wirtz (1911, p.195). No *Knappschaft* took advantage of the new rules. Rather, they stopped giving sick pay for Sundays, and introduced a waiting period (*Karenzzeit*) of three days before a worker became eligible for sick pay.

The *Knappschaften* faced further changes when Bismarck's social insurance scheme included them in the general German insurance system. Conventional wisdom holds that Bismarck's social-insurance policies marked a revolution in the role of the European state in providing social welfare (for an overview, see Hentschel (1983)). Historians are less sure, stressing the degree to which Bismarck simply extended the key characteristics of the *Knappschaft* to ever-larger numbers of German workers (see, for example, Tampke (1982)). But the *Reich* policy reduced the autonomy the KV had enjoyed since the 1850s, and once the *Reich* scheme was introduced, the KV comprised a small part of a very large system. Figure 1 reports the KV's share of all workers insured under Bismarck's social-insurance funds. The changes in the KV's relative share reflects the growth of the larger system, which kept adding to the groups of workers that were covered, as well as differential growth rates for workers in mining and other covered areas. From the first of January 1887, *Knappschaften* were required to meet the standards of all other German sickness insurance funds (*Betriebskrankenkassen*). The new rules required many KV to increase both daily sick pay and the length of time workers could claim this benefit. In 1903 the *Reich* further increased the minimum benefits paid by institutions such as the *Knappschaften,* and, as of the first

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and the „Instruction zur Einrichtung und Führung der Knappschafts-Casse für die Bergwerke im Herzogtum Cleve, Fürstentum Moers und Grafschaft Marck vom 16. Mai 1767."

[5] The three laws were: Gesetz vom 12. Mai 1851 betr. die Verhältnisse der Miteigentümer eines Bergwerks. Gesetz vom 10. April 1854 betreffend die Vereinigung der Berg-, Hütten- und Salinenarbeiter in Knappschaften. Allgemeines Berggesetz für die preußischen Staaten vom 24. Juni 1865.

[6] This only applied if the firm paid at least one-third of the *Knappschaft*'s costs. Firms were required to contribute at least one-third but could and did contribute more. Haftpflichtgesetz betreffend der Verbindlichkeit zum Schadensersatze für die bei dem Betriebe von Eisenbahnen, Bergwerken, Fabriken, Steinbrüchen und Gräbereien herbeigeführten Tödtungen und Körperverletzungen vom 7. Juni 1871, §4.

of January 1905, the duration for sick pay increased to twenty-six weeks, coupled with increased sick pay per week.[7]

Our discussion focuses on Prussia and Bavaria, which between them accounted for the vast majority of *Knappschaften* and members. Prussian legislation was also influential in the rest of Germany. Bavaria, for example, adopted the 1865 Prussian law almost without changes.[8] The important exception to Prussian influence was Saxony, which went its own way. Unfortunately, the information we use in our econometric analysis is not available for Saxony.

Internal management of the Knappschaft

After 1865, the *Knappschaften* were no longer run by state officials. From the Middle Ages the miners had elected a body called the Elders ("*Knappschaftsälteste*") who advised the state officials running the institution. With the reforms of the 1850s, the roles of the firm and the membership in running the *Knappschaften* became more formal. Each local organization had a managing board (*Vorstand*) consisting of equal numbers of representatives chosen by the owners and by the *Älteste* (Imbusch (1910, p.25)). Under §167 of the 1865 law, the *Älteste* selected as worker representatives either *Knappschaft* members or royal or private mining officials (*Beamten*). These representatives could be employed by another mine (Brassert 1888, p.471). Most sources agree that in practice, the firm's views dominated the *Vorstand*'s decisions. As one historian puts it, "In reality the owners had, during the entire history of the *Knappschaften*, a practical dominance that they knew how to use. Ordinarily the chair of the *Vorstand* was an owner representative, and the owner's representatives often outclassed the *Ältesten* intellectually…" (Lauf (2006, p. 272)). Imbusch (1910, p.64) argues the same.

The *Knappschaften* divided their members into two groups. *Ständig* members ("established") had greater rights to benefits than did *Unständige* (unestablished) members. Some sources suggest that *Unständige* members earned high wages, as one would expect.[9] *Knappschaften* could and did further subdivide their members into many more classes. *Ständig* members included managers as well as miners who had successfully completed a probationary period in the mines. The distinction remained, but in the nineteenth century the government required the *Knappschaften* to extend more benefits to the *Unständige.*[10]

The most important decisions for any *Vorstand* were the basic policy matters of how much to offer in benefits and how to structure those benefits. As already noted, some of these decisions were constrained by *Reich* rules by the end of our period. The managing committee also had to decide on contributions. In practice, *Knappschaften* set contributions in a given year with an eye to expected costs, but also relied on reserve funds to correct for over- or under-estimates. In the next year they could adjust contributions to try to return the reserves to the desired level.

[7] A special *Knappschaft* law in 1906 required separate accounting for the sickness and accident insurance component on the one hand and the pension component on the other. Because the *Knappschaft* could still apply reserves from one fund to the other, we doubt this had any real effect on the matters we study here.
[8] Imbusch (1910, p. 109) claims that the Bavarian organizations were even more fragmented than those in Prussia.
[9] Fischer (1961, p. 186). Murray and Nilsson (2007) show that in the Austria, which had a system similar to Germany, the labor market priced out the value of accident insurance coverage in such a way as to reduce the compensating differential for risk in wages.
[10] The official sources call these members *Ständig* und *Unständig*. Another term, used by both Köhne (1915) and Bülow (1905), is *eingeschrieben* (registered) and *uneingeschrieben*. The distinction is the same.

3. The broader implications of the *Knappschaften*

The *Knappschaften* will remind the reader of several different organizations that became prominent, and in some cases foundered, in the later nineteenth century. The issues discussed here are also central to broader themes in the development of social insurance and health insurance, in part because the German model has been so widely imitated. Some broader remarks will help situate what we can learn from the empirical results reported below. Perhaps the first institution to compare to the *Knappschaft* is the British Friendly Society.[11] Like the *Knappschaft*, the Friendly Society collected contributions from members and used those funds to provide benefits to members who became ill or died. The Friendly Societies also consisted of self-governing, local organizations (called "courts"), usually amalgamated into national organizations such as the Oddfellows or the Ancient Order of Foresters. But any further parallel is misleading. Friendly Society membership was strictly voluntary, and while overseen by a Registrar of Friendly Societies, the organizations were in essence free of government control. Riley (1997, p.37) stresses that to their members, the Friendly Society was as much about fellowship as financial security. A sick member could count on visits from other members, and his widow and orphan knew there would be a large turnout at a member's funeral. Accounts of *Knappschaften* sometimes stress the same idea, but, given the compulsion to join, the sense of solidarity doubtless was different.

The Friendly Societies' voluntary character led to problems that contemporaries and scholars alike hold central to their decline. First, because Friendly Societies refused to tie contributions to age, relatively few young, healthy people wanted to join. This is not the canonical adverse-selection problem caused by inability to separate potential members by their "type;" it was, rather, just that for a given annual membership fee and benefit package, only older individuals were willing to join. Riley (1997, pp. 289-291) notes that Friendly Society rules allowed them to deny membership to people who were probably bad risks, but that they rarely did so; "…judging from the way they operated, friendly societies did not expect to be able to distinguish good risks from bad risks with much accuracy." As a consequence, their membership grew older, and Friendly Societies found it harder and harder to fund the benefits their members expected. Some argue that this actuarial problem was central to their eventual demise.[12]

Knappschaft membership was compulsory, so the KV did not confront the adverse-selection problem that eventually undermined the Friendly Societies. But the German funds did face problems caused by changing demographics they could not control. If a mine was worked-out and employment contracting, the relevant *Knappschaft* would consist of older workers. We find that the *Simulation* problem was worse in *Knappschaften* with a contracting workforce. Some of this effect reflects the health problems of older workers, but controls for member age-structure suggest this effect is slight. The stronger influence seems to have been the knowledge that the firm and its KV were dying, and the desire to take advantage of benefits while they were still available.

The Friendly Societies also faced the question of who was sick and whether some illness reflected the equivalent of *Simulation*. The issue was the most frequent subject of discussion at local meetings (Riley 1997, p.99). He stresses that "friendly society members did not disagree among themselves about

[11] The Friendly Society also appeared in Ireland, most of the British Commonwealth, and many Continental countries.

[12] Wilkinson (1892) reported in 1892 that British Friendly Societies collectively had unfunded liabilities of more than ten million pounds. Gilbert (1965) argues that Friendly-Society opposition to universal old age insurance collapsed in the face of their own manifest inability to provide benefits, ushering in the 1908 Old Age Pensions Act. Emery (1996)'s analysis of U.S. and Canadian fraternal sickness funds shows, on the other hand, that inappropriate pricing was not a serious problem for them.

their ability, aided by doctors and sick visitors, to distinguish sickness from wellness" (Riley 1997, p.104). Friendly Societies adopted methods for controlling false claims that are similar to methods used by the KV discussed below. Some appointed a special "sick steward" whose responsibility it was to visit those claiming benefits to make sure they were really ill. Later on doctors were charged with a similar responsibility. Friendly Societies also forbad those who were claiming sick pay to appear at a pub (Riley 1997, pp.99-103).

Another group of institutions that evoke some of the same themes are Germany's credit cooperatives. Once again these institutions faced problems of possible adverse selection at both the membership-decisions and credit-decision stages, and any credit contract faces the possibility of moral hazard such as we study here. Guinnane (2001) argues that they devised ways to draw on the dense ties of information and enforcement, implicit in their local design, to overcome these problems. The cooperatives, like *Knappschaften*, appreciated the possibilities of scale but were concerned that a larger organization would increase information problems. Some rural cooperatives had formal rules that restricted their size and area of operations, for example. The credit cooperatives took advantage of both local information and economies of scale by creating specialist regional organizations to handle issues best dealt with by a larger organization (Guinnane (1997)). This approach resembles the ability to create local sickness funds that the *Knappschaften* rejected.

Models for sickness and accident insurance

A larger, comparative literature also bears on the *Knappschaften* because of the German social-insurance system's status as a model, positive or negative, for other countries. The connection is especially clear in discussions of the historical origins of the U.S. health insurance system – that is, why the U.S. does not have universal health care until recently. Two recent contributions to this vast literature help frame the issues. Murray (2007) considers the actual sickness funds in operation in the U.S. in the late nineteenth and early twentieth centuries, as well as the European (really, German) models many U.S. Progressives wanted instead. Many U.S. workers were insured by schemes that covered them either through their union, or through their firm, or by virtue of their membership in a voluntary sickness fund that might or might not have been, formally, a Friendly Society. Murray argues that most workers prized this coverage not because of provisions for doctors and related medical-care costs, but because the funds replaced part of lost wages when a worker was ill. Doctors and hospitals could not do much for workers (or at least the workers thought). Sick pay in the U.S. funds gave rise, not surprisingly, to the same problems and arguments as in Germany; employers thought sick pay encouraged absenteeism, but others thought the benefits of a healthy and loyal workforce offset any costs associated with malingering. In Murray's view, the Progressive insistence on a German-style system for the U.S. reflected either purely political motives, or misapprehensions about what the U.S. already had, coupled with an idealized understanding of what the European systems had achieved. Murray acknowledges that some features of the German-style systems (such as compulsory membership) obviate some of the problems facing the U.S. funds at the time, but insists, rightly, that any insurance scheme faced information and incentive problems that the Progressives were simply ignoring.

A second view, most recently articulated by Klein (2003), dismisses the various sickness funds operating in the U.S. in the early twentieth century as inadequate or ineffective at best, and tools of devious employers at worst. Her disagreement with the kind of argument represented by Murray is based on two differences in approach. First, she and others who take this view probably do not appreciate how

large (and, given that most were voluntary, popular) these U.S. sickness funds were. They did not approach anything like universal coverage, but neither did the German-style systems in their early years. Second, there is a tendency to judge these funds by a standard different from what workers at the time valued. They were not medical-insurance funds; that is not what workers wanted, and to judge them by that standard is a curious confusion of modern concerns with historical explanation.

4. The problem of "*Simulation*"

Some of the complaints about *Simulation* had a moralistic, anti-worker tone. The central issue is that the *Knappschaft* was insuring on an unobservable, the worker's health status. Consider as a simplification a myopic worker's one-day problem: whether to work or to report sick. A worker earns a wage w from a day of work. Each day he draws a health status z, where z is a uniform random variable distributed on the [0,1] interval. For each day he works, the workers receives utility from income u(w) and a disutility of work that depends on his health status z, c(z). The utility function has the usual properties, while c(z) is increasing in z, so a higher z denotes a worse health status.

Assume first that a miner who does not work earns nothing, that is, there is no sick benefit. In this situation a miner works if $u(w)-c(z) > u(0)$ or $u(w) - u(0) > c(z)$. For a given w, we can define a health status z* implicitly such that a worker is indifferent between work and reporting sick, $u(w)–u(0)= c(z^*)$. On any given day, workers with health status $z \geq z^*$ call in sick. Now suppose that a sickness fund introduces a program under which workers pay a proportion $(1-\alpha)$ of their wages into a fund used to pay a benefit b to miners who call in sick. Miners will now work if $u(\alpha w)-u(b)>c(z)$. We can define z^b implicitly as the health status realization that makes an insured miner indifferent between work and claiming benefit, $u(\alpha w)-u(b)=c(z^b)$. Clearly $z^b < z^*$; a fraction of workers equal to $z^* - z^b$ would work if there is no benefit, but call in sick because the *Knappschaft* will pay b.[13]

Many observers referred to *Simulation* when increases in sick pay prompted more miners to report ill. For example, Bülow (1907, p.64) notes that after the introduction of new rules in the districts of Bochum and Essen, the *Knappschaften* there experienced a strong increase in "*Simulation und Verschleppung*" of diseases. The situation only improved when sick pay was cut by one-third.[14] What observers wanted, apparently, was to be able to increase benefits for workers so that those with $z > z^*$ would have higher incomes, but without inducing any additional workers to report sick. But this was unrealistic. Health status was imperfectly observable; without additional measures, it would be only rational for workers with status from z^b to z* to take advantage of the benefits scheme. This is why *Knappschaften* introduced waiting periods and various control mechanisms (Bluma, Schulz, and Streb

[13] Modern studies of the effect of unemployment insurance and related programs identify the "replacement rate" or benefits as a fraction of working pay, as a key control variable. In our terms this is $b/\alpha w$. We do not observe this measure in systematic fashion. Lauf (2006, p.281) reports that the *Knappschaft* in the Rhein and Ruhr areas paid about sixty percent of the daily wage for sick workers. Other accounts sound similar. This sick pay was in addition to the costs of medical attention and supplies.

[14] „Es zeigte sich bald nach der Einführung des neuen Reglements, dass die Vermögen der Knappschaftskassen keinen merklichen Zuwachs mehr erfuhren, indem die Ausgaben die Einnahmen fast völlig aufzehrten. Dies hatte seine Ursache wesentlich darin, … dass die Krankenschichtlöhne zu hoch angesetzt waren, wodurch zu manchen *Simulationen und Verschleppungen von Krankheiten* Anlass gegeben wurde. Eine oberbergamtliche Verfügung betr. Verhütung von Simulationen, nach der das Krankengeld erst vom fünften Tage ab und nach erfolgter *Konstatierung der Arbeitsunfähigkeit durch den Bergarzt* verabreicht werden durfte, schuf keine Besserung. Erst als am 31. Juli 1834 die Krankenlöhne auf 2/3 des früheren Betrages heruntergesetzt wurden, erzielte man wieder günstige Kassenabschlüsse, so dass die Vermögen der Kassen sich von Jahr zu Jahr recht erheblich steigerten."

(2009)), and why many observers thought it important to use social pressure to induce miners to refrain from calling in sick, even when their health status was worse than z*.

Simulation could mean, as critics claimed, that a perfectly healthy miner would get out of bed one morning and decide that he would rather go fishing, or work in his garden, than go into the mines. The greater the replacement rate, the greater the incentive to take a week off at *Knappschaft* expense. Workers also took off time to heal from miner illness of injury. Mining was hard, dangerous work. Miners would come home from a day's work with bruises and muscle strains that required several days' recuperation. The miner could, in fact, work the next day, but had good reason not to want to. The effect of the *Knappschaft* benefit in this less moralistic exposition is to reduce the cost to the miner of time to heal. Allowing miners to recuperate fully might well have been efficient rather than evidence of incentive problems. A third behavior is also relevant. *Simulation* and *Verschleppung* are both translated in English as "malingering," but the former implies that the condition is invented, and the later implies that the condition was real but the sufferer has exaggerated its duration. The idea here is that a worker really was ill for three weeks, but reported ill for an additional week because of the moral hazard problem.

The literature makes several suggestions as to why *Simulation* increased in the later nineteenth century. Some authors argue that the 1854 Prussian law, which converted miners from a privileged *Stand* to ordinary proletarians, was the root of the problem. Lauf (2006, p.266) refers to a wave of protest at the demotion of the *Knappschaft* from the institutional symbol of that special status to the more prosaic role of insurance provider. We cannot test that claim, as the change proceeds the period for which we have useful data. Two other claims are testable. The first is that KV size promoted moral hazard. In a large *Knappschaft* a miner felt less that abusing the system was hurting someone to whom he had real social ties. Observers often noted that miners were in a better position than others to know who was really unable to work, and that the risk of ill-will from fellow miners was an effective deterrent. This amounts to imposing an additional disutility, in the form of worker opprobrium, on those who call in sick when they in fact have a low draw of z. In this case the *Knappschaft* could increase b without increasing the numbers calling in sick; in effect, this extension relies on the assumption that fellow miners could overcome the assumed information problem.

Large *Knappschaften* could certainly undermine the informal controls that made the organizations work. Members in larger *Knappschaften* could well never see each other. They often worked in widely-disbursed pits and work would never bring them into contact. Some KV were huge, and some enterprises had grown so large that it would be hard to feel any sense of solidarity just within the single enterprise. In our data, for example, the median works has 121 *Knappschaft* members employed. But one KV had over ten thousand workers. There were frequent claims about the relationship between KV costs and either the *Knappschaft*'s size (membership) or the area over which it was spread. A large or spread-out *Knappschaft* exacerbated moral hazard by making it more difficult for workers to observe each other. In discussing Saxon *Knappschaften*, Elsholz (1910, p. 36) explicitly argues that in a small organization workers will work to control costs, and that if they are spread out in several different mines this is not possible. "…For sickness funds, small and local organizations (*Gebilde*) are needed, because the funds benefits if workers have an interest in thwarting *Simulation.*" Simons (1895, p. 8), Wirtz (1911, p.105), make similar arguments, and Lauf (2006, p. 271) notes that the need to reduce the size of the insured group was a theme from the 1880s.

The *Reich*'s interventions, requiring greater sick pay and longer periods of coverage, also contributed to the problem. Higher sick pay would, *ceteris paribus*, lead to more *Simulation* by reducing

the cost of time off. The longer benefits period would also encourage *Simulation*. The waiting period (*Karenzzeit)* is like an investment for the worker; by extending the benefit period, the government reduced the cost of that investment relative to the payback.

A final argument implies that the sick pay was being used as a substitute for unemployment insurance. Several commentators noted that *Simulation* became a more serious problem during downturns in the covered industries. Sick pay was set as a fixed daily sum, but the worker's income depended on demand for their product.[15] This implies that the replacement rate varied over the business cycle, increasing as economic conditions worsened. In the 1870s, for example, a serious downturn reduced the demand for coal and thus the miners's daily income from work. Bry (1960, Table A-8) reports an index of shift earnings for Dortmund miners. This index (1913=100) falls from 77 in 1873 to 39 in 1879. Overall, the coefficient of variation for the index in the period 1871-1914 is 27 percent, indicating that miners faced large fluctuations in the demand for their labor. This situation led to considerable *Simulation*, according to Menzel (1989, p.102) who quotes an 1894 eyewitness at a later date. *"... Simulation* increases especially in bad times. When wages fall, that is, when workers worked only part time, then the experience is that sicknesses increase and with them the costs for the sickness fund." Menzel's eyewitness also claimed that firms *encouraged Simulation* in downturns, tacitly turning the *Knappschaft* into a form of unemployment insurance.

Combating the problem

Knappschaften were aware of the problem and adopted measures to reduce *Simulation*. Some tactics took for granted that additional information on the health status of the miners would be too difficult to acquire, and instead tried to create the desired separating equilibrium by reducing the attractiveness of being ill while holding sick pay fixed. Some KV required that those receiving medical treatment and sick pay remain in hospital (*Lazarettezwang*). Miners detested this policy, although we cannot say whether it was because it made recuperation more unpleasant or malingering harder. According to Lauf (2006, p.284), the rules of the Upper Silesia association required *all* illness to be treated in hospital.[16] The results of the policy were impressive: for the period 1901-1908, this Knappschaft experienced 6.4 sick days per member, compared to 10.8 for other Prussian *Knappschaften* and 7.6 for Germany as a whole. Köhne (1915, p.38) notes a similar policy in a different context, with the same results. Unfortunately, we cannot test the implications of the hospitalization policy directly.

[15] Ashton (1916) notes this same effect for the British Amalgamated Society of Engineers. Whiteside (1987) discusses the same issue for Britain in the 1920s and 1930s. German miners were paid a team piece rate. The rate was re-negotiated at regular intervals, implying that the rate would track current output prices. See Banken (2000, pp.100ff).

[16] We have not been able to determine when this rule was introduced. Lauf (2004, p.153) reports that in 1857 this *Knappschaft* already had ten hospitals. According to Köhne (1915, p. 38), „Besonders intensive Krankenhauspflege ordnet der Oberschlesische Knappschaftsverein an, der eine ambulante Behandlung seiner Mitglieder nicht kennt, sondern in allen Erkrankungsfällen die Unterbringung in einem Krankenhaus anordnet. ... Die Erfolge des Oberschlesischen Knappschaftsvereins mit seinem so genannten Lazarettzwang sind gut. ... Die Bergleute empfinden den Lazarettzwang als Freiheitsbeschränkung." Imbusch (1910, p.42) agrees, noting that this *Knappschaft* owned nine of its own hospitals, and that in 1881, 69 percent of its sick members were treated there (the implication being that the rest were treated in hospitals not owned by the *Knappschaft*). This hospital rule echoes the arguments made for the "workhouse test" under England's New Poor Law. The workhouse was expensive, but by forcing paupers to receive relief there, the workhouse both screened out applicants who were not truly in need, and it increased incentives to take actions that would keep the person from needing the Poor Law (Besley, Coate, and Guinnane 2003)

Knappschaften were also aware of the role the waiting period (the *Karenzzeit*) played in discouraging *Simulation*.[17] Wirtz (1911, p. 106) notes that when the Ruhr *Knappschaften* introduced a policy in 1867 of making claimants wait three days (not including a Sunday) to receive payment, they could increased sick pay per day by fifty percent and still reduce total costs. Note that the implications of the *Karenzzeit* for *Verschleppung* are different. For someone who really was sick for three days, this policy does not change the *marginal* cost of additional days of "sickness."

Other policies tried, in effect, to develop better information on who was truly ill. Smaller *Knappschaften* hired local doctors on a part-time basis, while larger associations had full-time staff. Most doctors were assigned a specific set of workers as their responsibility, and were paid a fixed sum per worker per year, *healthy or ill*. This might have reduced simulation if the doctor would reduce his time commitments by refusing to coddle miners who were not ill. On the other hand, the doctor might have found it easier to accede to miners' demands that were not medically justified. This "parish" (*Sprengel*) system for doctors preceded the 1865 reforms; Bülow (1905, p.33) reports its existence in the Märkischer KV from 1840.

In other cases, the Elders or their designees oversaw designation of sick cases. This naturally made the Elders less effective as worker representatives, because they were in effect policing *Simulation* and were thus resented by workers. Some *Knappschaften* hired additional employees to help deal with the problem. The Bochum *Allgemeine Knappschaftsverein* introduced in 1893 a system whereby trustees (*Vertrauensmänner*) could pay home visits to any worker who claimed to be ill. They visited nearly forty percent of sick members (Lauf 2006, p.288), a figure high enough presumably to worry those who made false claims. Bülow (1905, p.34) notes that the *Märkischer Knappschaftsverein* introduced a special "sickness controller" for Bochum in 1860, but that, in the face of considerable protest the *Älteste* backed down. If this type of system could be made to work, it would reduce all three kinds of *Simulation*. But Riley (1997, p.101) argues that the equivalent in Friendly Societies were viewed as spies. To the extent the *Knappschaft*'s methods undermined the solidarity that made miners think of the organization as their own, such methods could backfire.

5. Empirical strategy

The rest of this paper reports indirect tests for the existence of moral hazard. We rely heavily on the rich annual reports the *Knappschaften* made to either the Prussian or Bavarian governments. The data were published separately for each *Knappschaft*, grouped together in large administrative districts (*Oberbergamtsabezirk* in Prussia*, Berginspektionsbezirk* in Bavaria*)* that correspond to the government apparatus for oversight of mines and *Knappschaften*. The districts are named for the cities where their offices were located: Bonn, Breslau, Clausthal, Dortmund, and Halle in Prussia; and Bayreuth, München, and Zweibrücken in Bavaria. Figure 2 is a map of Germany, using its pre-1918 borders, that locates each region. Appendix A gives precise sources for the variables we use. These regions comprise the primary mining areas located in Prussia, as well as most of those located in Bavaria, and include the vast majority of all *Knappschaften* in Germany. Our data allows us to overcome problems that have limited earlier efforts to examine moral-hazard and related problems in historical sickness funds. We know the age-composition of our KV members, for example, and can control for that in our models. More generally, our panel allows us to experiment with controls for unobserved heterogeneity among *Knappschaften*.

[17] Friendly Societies used a similar waiting period (Riley 1997, p.283), as did many of the sickness funds studied by Murray.

One reason *Knappschaften* varied greatly in size was that some small ones merged. Sometimes the resulting *Knappschaft* was new (that is, it did not exist until the fusion) while other times a small one was merged into a pre-existing *Knappschaft*. Prussia saw a long series of fusions in which a larger KV absorbed a smaller. (Figure 3 and Table 1 report the number of *Knappschaften* by district.) Sometimes the same KV was involved twice; the Märkischer KV, for example, absorbed the Königsberger KV in 1877, and in turn was one of the three *Knappschaften* that merged to form the huge *Allgemeiner Knappschaftsverein* Bochum in 1890. Fusion was less common in Bavaria, although in 1902, ten KVs joined to form the new *Knappschaftsverein* Bayreuth.[18] The possibility of fusion raises a problem that we do not address in this paper: at some level, *Knappschaft* size was endogenous. Suppose the member's desire to keep their small organization separate reflected, in part, their fear that the members of a larger organization would have different preferences, and that the preferences of the original members not be reflected in the policies of the new body. This logic implies that size is correlated with member preferences, which makes size endogenous in the models we estimate. We have a partial defense for our current approach. In some cases the government "suggested" that small *Knappschaften* merge. We do not know the full range of pressure the government might have brought in those cases, so cannot speculate on how voluntary mergers really were. To the extent they were not voluntary, we are on firm ground in our current approach.

We have been unable, despite considerable effort, to locate archival material that would allow us to examine the effect of *Knappschaft* policies on the behavior of individual workers. We are forced to work with aggregates by *Knappschaft*-year. Thus we are unable to determine whether a particular policy affects all members a little or a minority of members a great deal. There are two other limitations to the data. The first is some missing years, which we do not think we can overcome because the *Knappschaft* never sent in the requisite report. For single years this problem is not terribly important; it just means that our panel is not quite fully balanced.[19] The greater challenge is a lack of consistency across *Knappschaften* and years in the way information was reported.

Econometric issues

We report only fixed-effects (FE) and pooled estimates of our models. Hausman-type tests for our models consistently reject the consistency of the random-effects estimator. The substance of our data also suggests the fixed-effects model; we have the universe of *Knappschaften*, not a sample.[20] The more

[18] The only other fusion in Bavaria in the relevant period took place in 1905.

[19] The panel is also unbalanced because of the way we treat the fusions.

[20] One might argue for an alternative approach based on the "between effects" (BE) estimator, which estimates the model parameters using variation across KV, rather than within KV (as with the FE estimator). We believe the FE to be the better approach, because it allows us to clean out unobserved heterogeneity at the KV level. We did estimate all FE models reported here with the BE estimator. The results differ (if the BE and FE estimates were identical, then the random effects estimator would be consistent) but the BE models do not overturn the qualitative implications of what we report below. We do not report detailed results relating to two other issues. One might think that if sickness reflects persistent shocks to the KV, our data would observe an AR(1) or AR(2) process. This possibility implies that our estimates are consistent (but inefficient) and that our standard errors are incorrect. We re-estimated the models reported here using a HAC estimator. The point estimates are nearly identical to those we report. The standard errors are usually larger, but the t-ratios rarely fall below conventional significance levels. More seriously, the process we are modeling might be dynamic, in the sense that outcomes today would depend on outcomes in prior years. For example, suppose the *Knappschaft* experiences a year in which many members claim sick pay. This might provoke an effort, in the next year, to be stricter about controlling who gets such benefits. This example suggests a dynamic relationship that would bias our estimates if we did not take the dynamic structure into

important issue facing this research concerns the potential endogeneity of an important regressor. We do not have precise information on the benefit schedules for workers in the various *Knappschaften*. Instead, we use the *average* benefit, computed by dividing total sick benefit payments by the total number of days the benefit was paid to members who received such payments (*Sick pay per day*). This variable reflects the balance of two forces. First, a higher replacement rate would encourage workers to report ill. Second, a higher replacement rate encourages the KV to take stronger measures to control *Simulation*. *Sick pay per day* is arguably endogenous, because a *Knappschaft* whose workers experienced higher rates of sickness would want to reduce benefits. The effect could also appear over time; as sick days increased, the KV could react by reducing sick pay, as several of our examples imply.[21] As an instrument for *Sick pay per sick day* we require a variable that is correlated with sick pay but uncorrelated with the error term in our second-stage equation. The IV results reported here all use the firm's contribution per KV member as an instrument for the generosity of sick pay. This instrument meets the exclusion restriction, as there is no reason to think miners cared about the firm's per-member costs in deciding whether to report sick. The "first-stage" regressions we report below also show that the instrument is strongly correlated with the endogenous variable, as it must be.[22]

In much of our analysis we divide the *Knappschaften* into two groups and estimate separate but identical specifications.[23] This approach reflects the robust finding that larger, more rapidly-growing KV behaved differently from the smaller, shrinking associations. We cannot say precisely why this relationship holds so strongly, but suspect that it reflects differences in perceptions of the future. A worker presumably thinks differently about abusing an institution he doubts will exist in ten years. One could think of the distinction as size or growth rate of membership. The growth rate distinction is more robust. The precise dividing line does not affect the results; here we split the data at the median growth

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account. We re-estimated the models reported here using versions of the Arellano-Bond dynamic panel estimator. That model relies on the assertion that first differences in the exogenous regressors can serve as instruments for the (endogenous) lagged dependent variable. In our case, first-differencing results in the loss of many observations, given the lack of full balance in the panel. Estimating our models for a subset of KV with complete data leads to two generalizations about the dynamic model. First, the dynamic specification is better in the sense that the lagged dependent variables are statistically significant at conventional confidence levels. The second-period lagged dependent variable tends to be more important than its one-period lag. The relationship is unexpectedly positive; more sick days in the previous period implies more today. This result is contrary to our expectation, because we had assumed the KV would react in ways that would reduce sick claims. Second, the results of interest do not change materially in the dynamic specifications. In most specifications the effects of interest have the same signs and similar magnitudes, but the standard errors are larger.

[21] During the downturn of the 1870s the Ruhr *Knappschaften* faced declining contributions. Their reaction illustrates the endogeneity issue: "… An der Höhe der Kassenleistungen, das wurde als Grundsatz aufgestellt, sollte nicht gerüttelt werden, und ein Antrag auf Ermächtigung des Vorstands zur zeitweisen Ermäßigung des Krankengeldes bis zu 75% wurde abgelehnt. Nach einigen Monaten jedoch, als sich zeigte, dass im Essener Verein das Defizit im laufenden Jahr noch größer geworden war, wurde in diesem Punkte der Nachtrag zum Essener Statut nochmals und zwar dahin geändert, dass alle *Krankengeldsätze* durch den Vorstand um 1/5 ermäßigt werden sollten. Eine Erhöhung war erst für den Fall wieder in Aussicht genommen, wenn nach dem Ermessen des Vorstandes die Kasse die erhöhten Leistungen wieder tragen konnte und das Verhältnis von Löhnen und Krankengeldern eine Erhöhung nach dem Urteile des Vorstandes wieder zuließ (Wirtz 1911, p.112).

[22] Recent discussions of the problem of weak instruments suggest as a rule of thumb that the F-statistic associated with exclusion of the instrument in the first stage be at least 10. We report t-statistics, which in this case are the square root of F, and in most cases they exceed the relevant value of 3.16. For a cogent discussion of the weak-instrument issue, see Bound et al (1995).

[23] In some IV specifications for the stagnant KV, the point-estimates are worryingly large but imprecisely estimated. This reflects a scaling problem, not a specification error. We retain the current scaling to make all regressions easily comparable.

rate of 1.8 percent per year. Splitting the data at a growth rate of zero produces nearly identical results, as does dividing the *Knappschaften* according to membership size, with the dividing line at 200 members.

Definitions and proxies

We use several proxies and definitions that require discussion. Table 3 defines and gives descriptive statistics for each of the variables in our regressions. We employ two different measures of the size of the meaningful unit in which workers operated. One is the total size of the KV (*KV members*) while the other is the number of members per works (*Workers per unit*). Another important variable is the fraction of total KV expenses born by the owners (*Firm's portion of costs*).

Some arguments made by contemporaries imply that *Simulation* would respond to the demand for miner's labor. To test this claim precisely would require KV-level production data, which is not available. As proxies we have assembled annual data on output of key products such as coal. Unfortunately this information is not available at any level less aggregated than the *Oberbergamtsbezirk*. The production data are also only available for Prussia. We experimented with the production of hard coal (*Steinkohle*) and soft coal (*Braunkohle*) as reasonable proxies. In some specifications we interact them with a dummy for whether the KV in question had any mines of that type; in others, we found that hard coal (*coal production*) production alone was a good proxy.

Empirical implications of Simulation and Verschleppung

We employ two distinct strategies for identifying *Simulation*. Our first strategy relies on the fact that some diseases are more easily verified than others, and thus speaks directly to the underlying issue, which is the imperfect observability of health status. Presumably a miner who claims to have a broken leg cannot fool his doctor about this fact. But other diseases were another matter. Contemporaries focused on the fact that rheumatism was a sort of unverifiable catch-all term. Today we associate rheumatism with conditions that are real and in most cases subject to clear-cut medical tests. We do not mean to suggest that many miners were not suffering from the same. But it was easy in the nineteenth century to claim rheumatism as a cover for *Simulation*. Menzel (1989, p.186) cites a *Knappschaft* doctor who claimed that "The word 'rheumatism' excites in the populace a general sympathy, pleasing both patient and doctor. …nobody knows what rheumatism is. The word serves often as a cover for ignorance, as the last refuge in cases where the doctor seems to have been convinced that his patient, although objectively in good health, is suffering."[24] Dr. Schlockow (1881, p.160) drew a direct connection between rheumatism reports and *Simulation*, noting that this condition was easier to fake than others. He buttresses this view with the observation that in the Upper Silesian *Knappschaft*, where sickness had to be treated in hospital, rheumatism affected 4.8 of every hundred members per year. The similar figure for Clausthal was 26.7!

[24] „Das Wort *Rheumatismus* erfreut sich im Volke einer allgemeinen Sympathie, es befriedigt den Patienten und selbst den Arzt. Leider ist es seit der Wirksamkeit der sozialpolitischen Gesetze, wie sehr auch die Wohlthaten derselben anzuerkennen sind, noch mehr zu Ehren gekommen, obwohl niemand, selbst der Arzt nicht, weiß, was Rheuma ist. Das Wort dient gar zu häufig als Deckmantel der Unwissenheit, als letztes Refugium in den Fällen, in welchem der Arzt die Überzeugung gewonnen zu haben scheint, dass sein Klient, obgleich den objektiven Erscheinungen nach gesund, dennoch leidend ist." Deshalb schlägt Tenhold vor: „Die Diagnose ‚Rheumatismus und Neurasthenie' von den Krankenscheinen wenigstens ganz zu verbannen. In den meisten Fällen, wo solche Diagnosen vorliegen, wird man entweder eine bestimmte Organerkrankung nachweisen oder den Mann, sei es der Übertreibung, sei es der *Simulation*, überführen können."

Our second strategy corresponds to the approach taken in earlier work on this topic, and is more severe. If illness were perfectly observable and caused only by random shocks, as one expects, then there would be no relationship between sick days and the size or source of payments to workers. Similarly, sick days would not be associated with the size of the KV or individual production units. The second set of models all rely on the presumption that such correlations reflect some type of moral hazard. A concern is that these correlations could arise out of omitted variables bias or some other specification problem. Suppose, for example, that work in larger production units is objectively more dangerous than in other contexts. Then a finding that reported sick days increased with the size of the production unit would not necessarily be evidence of moral hazard alone. To the extent this unobserved heterogeneity is linear and additive, our fixed-effects models will sweep that away. We recognize that this second group of tests is demanding.[25]

6. Evidence from causes of illness

The apparent incidence of rheumatism varied dramatically across KV. In the median year, most *Knappschaften* saw fewer than ten such claims per hundred members. The exceptions tended to be extreme. The Neusalzwerker KV had 55 claims per hundred members in some years. More instructive is the apparent persistence of this rheumatism crisis. For three-quarters of the years in our data, the Neusalzwerker KV had at least 47 reports of rheumatism per 100 members. This empirical pattern suggests a simple test for the presence of moral hazard: do lost work days due to rheumatism vary differently from reports of other causes of illness? More precisely, do the determinants of rheumatism cases suggest that it was used, as suggested, as a cover for *Simulation*? As a control, we compare the data on rheumatism to the data on bruises and contusions (*Quetschungen*).[26] Contusions were a fact of life for miners, and legitimately led to lost days of work. But unlike rheumatism, contusions are normally entirely observable to a medical practitioner. Moreover, most accidents leading to bruises and contusions would be well-known to other miners, whereas a worker with true rheumatism has no way of credibly signaling that fact to his fellows.

Figures 4 and 5 report the unweighted means and standard deviations of the incidence of rheumatism and contusions in Prussia (Bavarian *Knappschaften* did not report this information). Two patterns stand out. Over the period for which we have this information (1867-1884), rheumatism became relatively less common, but it varied much more dramatically over time than did reports of contusions. Figure 5 shows that the dispersion of apparent rheumatism across *Knappschaften* was significantly greater than for contusions. The information contained in these graphs strongly suggests that rheumatism was being used as a cover for *simulation*; the underlying "true" causes of the condition would not vary as much over time or across *Knappschaften*. Table 4 reports FE estimates of the determinants of the difference between reported rheumatism and contusions in a given KV, separately for the stagnant and dynamic KVs. This "difference" approach allows us to control in a clean way for cross-KV differences in factors that affect

[25] Several earlier studies test for moral hazard in funds of this type. Our sick pay measure is identical to that used by Murray (2005). Our approach in section six is also very similar to his. Our data differs from earlier studies in two respects. Some datasets have individual-level data on actual or potential fund members (for example, some sources used in Murray (2007), as well as Gottlieb (2007)). This type of source permits modeling of the observed worker-level heterogeneity, but these sources are always a single cross-section, and thus make it difficult to distinguish moral hazard from unobserved heterogeneity. (Murray (2005) also uses a panel in which the observations are country-years). Our dataset is unusual in that it is *fund*-level

[26] Some KV reported various types of rheumatism and contusions. We aggregate them into two general categories.

either type of illness. We estimated (but do not report) separate models, and those suggest that most of the correlation between the difference and the right-hand side variables in our models reflects correlations with rheumatism. The models discussed in this section tend to be fragile. We experimented with several different approaches. The underlying problem is that data on illness stops in 1884, and some KV were not always consistent in even reporting the data. Table 5 reports elasticities pertaining to the models reported in Table 4.

The instrument for *Sick pay per sick day* here is as noted above; the F-statistic for the instrument in the first stage exceeds 3.5 for each model except column (2). Re-estimating that particular model without the instrument produces, not surprisingly, results similar to those reported. The models include year effects, but they are not statistically significant. The results show that rheumatism responded strongly to increases in *Sick pay per sick day* and, for stagnant KV, to increases in the portion of total costs covered by the firms. The pooled model for stagnant *Knappschaften* explains a relatively large portion of the variation in the dependent variable. Only in the dynamic KV do we see any evidence of two other issues stressed by contemporaries. *Knappschaften* with a larger overall membership, in the pooled specification, had significantly less rheumatism. This may reflect a scale economy in measures to control *Simulation*, such as a hospitalization policy. And dynamic KV saw relatively less rheumatism when hard coal production increased. This finding is consistent with the claims that reduction in miner pay affected *Simulation* by changing the opportunity cost of a day off work.

7. Evidence from sick days and cases

The rheumatism proxy yield sharp, clean results, but only for part of our period. We turn next to measures of the overall behavior of miners in a *Knappschaft*: how many claimed to be sick and for how long, and how those measures varied with the incentives to make false reports. There are several ways to measure the extent to which miners drew on sick pay. One measure is available for all KV for the entire range of our dataset, and that is the total number of sick days for the *Knappschaft* in a year, divided by its membership in that year. Only the Prussian KV reported the data needed for two additional measures, unfortunately. One is the total number of *cases* of illness in the year, and the second is the mean number of days lost *per case* of illness.

We begin with days of illness per *Knappschaft* member, for which we have complete information. Table 6 reports three fixed-effects models each for all KV (columns (1)-(3)), for those growing more rapidly than the median (columns 4-6), and for those growing more slowly than the median (columns (7)-(9)). For each group we report a FE regression, an analogous FE IV regression, and the "first stage" from that IV regression. The first stage has independent, substantive interest, because it amounts to a model of how sick pay is determined. Our regressors include *Sick pay per sick day* and *Firm's portion of costs,* which reflect the extent to the miner can take a day off at someone else's expense, as well as two measures of size, *KV members* and *Workers per unit*, which measure the putative size effect in moral hazard. The regressions include the coal variable used in the cause-of-sickness regressions. We introduce dummies for 1887 and later and 1905 and later, to capture any influence of the *Reich* policy changes.[27] Table 9 collects the main elasticities from models we discuss in this section.

[27] These and later regressions include unreported controls for the age-structure of the Knappschaft's membership. Collectively these controls are always only borderline significant. Surprisingly, older workers seemed less likely to

The IV models demonstrate the importance of treating *Sick pay per sick day* as endogenous. In the basic FE model *Sick pay per sick day* has a negative effect, which is precisely what the reverse causation would imply. In the IV specifications it is always either positive or effectively zero, which is what we expect: the greater is sick pay, the greater the incentive to report sick. Focusing on the IV results, we see that the model does not explain behavior in the slow-growing KV well. Most impacts are imprecisely estimated. The best interpretation of the model is that these *Knappschaften* did not suffer moral-hazard problems that manifested in large numbers of sick days per worker. The results for the fast-growing KV are strikingly different. The IV estimate for *Sick day per sick day* is essentially zero, but *Firm's portion of costs* led to more reported illness, a sure indicator that workers conditioned their behavior on who was paying. In faster-growth *Knappschaften* the size of the unit has two effects. A larger KV *per se* leads to slightly more *Simulation*, while larger individual production units leads to much more. The second elasticity is much larger (.047) than the former (.020). If larger Knappschaften were able to capture scale economies to reduce the extent of *Simulation*, we would expect the first elasticity to be negative. Our coal-production proxy does not have the expected negative impact on sick days; greater production actually increases sickness, which is what one would expect if hard work leads to injuries.

The two mandates from the *Reich* each increased reported sickness for the dynamic KVs but not the others. The 1887 law, which made all KVs adhere to the rules for the other sickness funds, increased reported sickness by about 7 percent. The 1905 changes had a slightly greater effect. In each case, there were two important changes: minimum sick pay increased, and the period over which the miner could receive that pay increased.

We now turn to the "first stage" regressions, which in this case tell us how Knappschaften determined the level of benefits they offered. The model for the slow-growing KV does a much better job of explaining *Sick pay per sick day* than does the second stage. The 1887 reform forced all associations to increase sick pay. Other impacts differ across the two groups. A larger KV offers more sick pay to members in a dying KV but not in a dynamic one. Both types offer more pay if the production units are larger. Both pay more when demand for coal is high.

The models reported in Table 6 include the *Knappschaften* in Silesia. These KV all supposedly introduced a rule that required all illnesses to be treated in hospital, although we unfortunately do not know when the KVs adopted these rules. We are not convinced that the rules were enforced in any consistent way; the proportion of all illnesses treated in hospital in Silesian institutions varies widely across KV and even over time within a single association. On average, the Silesian *Knappschaften* treated 57 percent of cases in hospital. The next-largest proportion is in Bonn, with only 8 percent on average. But the distributions overlap. The Lower Silesian KV, for example, often reported as few as 10 percent of all sick miners treated in hospital. This different policy in Silesia raises the question of whether these *Knappschaften* should be included with others in our models. If it were really true that they forced all sick miners to hospital, then we should not, as all the incentives for *Simulation* would be different. To examine this question, we re-estimated the models reported in Table 6 separately for Silesian and non-Silesian *Knappschaften*. The results are slightly different, but none of our basic observations are overturned. So we continue to combine all the KV.

Ours is just one measure of moral hazard, but the results strongly suggest that contemporary commentators only partly understood the mechanisms underlying the growth of KV costs. The size

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claim sick pay. This correlation may reflect the practice of allowing older miners to shift to less dangerous work, often on the surface.

effects contemporaries emphasized were definitely present: *Knappschaften* with larger production units definitely experienced more sickness claims. But these effects are slight compared to the impact of more generous pay, especially when that sick pay is funded by the owners. And, to the extent our coal-production proxy is a good measure of the demand for miner labor, there is little evidence that the *Simulation* reflected disguised unemployment.

Cases of illness

We now turn to the number of *cases* of reported illness. The number of sick cases approximates the number of times a worker paid the implicit cost of the *Karenzzeit.* This information is unfortunately only available for Prussian KV. Table 7 reports models strictly parallel to those in Table 6, but this time the dependent variable is the number of *cases* of illness per *Knappschaft* member. In the IV results for all KV and for the dynamic associations, the signs on *Sick pay per sick day, Firm's portion of costs*, and the two size-of-association variables are as expected, and similar to the results in Table 6.[28] But we now see another impact of the 1887 and 1905 reforms. In both cases, the reported number of cases of sickness declines. In the absence of any change in *Knappschaft* practice, we would expect the *Reich* measures to *increase* reported sickness. Clearly this reflects the *Knappschaften* trying to control costs; if the number of illnesses had not declined, the greater sick pay could have overwhelmed the fund.

Length of illness

We turn now to the mean length of reported illness, which again is only available for Prussian *Knappschaften*. This dependent variable differs from the one used in Table 6 because we in effect condition on whether a member was ill at all. Table 8 reports regressions parallel to those in Tables 6 and 7. The results here contain some surprises. Increased sick pay *shortens* reported illnesses, the model claims (although the impact is not statistically significant in the IV specifications). The *firm's portion of costs* has a large, positive impact on the length of illness. The 1905 reform increased the duration of illnesses, but the effect is small if statistically significant. Table 8 illustrates the multiple tools available to *Knappschaften* that worried about *Simulation*. The 1905 reform, for example, doubled the maximum period for sick benefit. This would seem an invitation to *Verschleppung*, but the actual increase is rather small. This result presumably reflects the KV's fears about what could happen after 1905, and their efforts to combat the problem.

Table 9 reports elasticities from these last three models to summarize the determinants of our several measures of *Simulation*. There is no reason these impacts should all be similar; for example, when the *Reich* forced *Knappschaften* to extend more generous benefits, one might well expect that the KV would try to reduce *Simulation* and thus achieve a reduction in the number of sick cases (Table 7), leaving only the truly sick and thus long average periods of illness (Table 8). This outcome would have an ambiguous effect on overall sick days per member (Table 6). In any case, there are some overall generalizations to draw from our models. First, firms that shouldered a greater share of the KV's costs experienced higher levels of sickness. The same goes for *Knappschaften* with relatively large production units. That this effect is zero in the last model suggests that the information and informal sanctions available to workers in smaller enterprises only worked to discourage shorter periods of malingering. Finally, the two reforms in our period produced precisely what we would expect if there was significant malingering beforehand: when forced to pay greater benefits for a longer period, the *Knappschaften* found

[28] The first-stage results here differ from the early model because these data are only available for the Prussian KV.

ways to reduce the number of cases of illness (Table 7) at the expense of longer average illnesses. The later, of course, is not really a cost, if it meant the *Knappschaften* were now concentrating resources on the truly ill.

8. Conclusions

The *Knappschaften* grew out of medieval miners' efforts to insure themselves against the economic consequences of their dangerous jobs. By the late nineteenth century the KV were state-sanctioned, self-run sickness funds. Membership was compulsory for workers in covered industries, and the individual *Knappschaften* had considerable autonomy over important policy decisions. Bismarck's social-insurance legislation used them as the model for similar funds in other industries, and as such they remain the model for German illness and accident insurance today.

Late nineteenth-century observers noted that *Knappschaften* experienced strong growth in the number of days their members claimed to be sick. Contemporaries blamed this development on *Simulation*, or feigning illness, and thought it reflected changes in the miners' social status and the deterioration of social ties among KV members brought about by increases in the size and territory of individual associations. This paper uses aggregate data on the *Knappschaften* to test these claims. We find that there was indeed considerable *Simulation*, as suggested by huge variations in the incidence of rheumatism and its strong correlation with proxies for the attractiveness of feigning illness. Turning to the determinants of reported sickness itself, we find that in growing *Knappschaften*, miners were attuned to both the generosity of sick pay and the portion of the KV's costs paid for by owners. Contemporaries were also correct that as the units in which miners worked grew larger, apparent incidents of illness became more common. We find little evidence for a potential offsetting effect; larger *Knappschaften* apparently did not find ways to use their size to achieve efficiencies in monitoring, medical treatment, or both. Finally, we find that *Simulation* in the many shrinking *Knappschaften* took a different form; we know it was considerable, but it apparently was not strongly correlated with observable KV characteristics. Membership in a dying organization seemed enough to bring out the strongest moral-hazard problems.

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Table 1: Numbers of Knappschaften, by District, Prussia and Bavaria, 1861-1914[a]

	Prussia (*Oberbergamtsbezirke*)						Bavaria (*Berginspektionsbezirke*)			
	Bonn	Breslau	Clausthal	Dortmund	Halle	*Sum*	Bayreuth	München	Zweibrücken	*Sum*
1862	43	4	-	11	19	*77*	n.a.	n.a.	n.a.	*n.a.*
1867	47	4	-	15	19	*85*	n.a.	n.a.	n.a.	*n.a.*
1872	47	4	6	15	17	*89*	n.a.	n.a.	n.a.	*n.a.*
1877	45	4	9	14	12	*84*	n.a.	n.a.	n.a.	*n.a.*
1882	44	4	9	14	12	*83*	n.a.	n.a.	n.a.	*n.a.*
1884	44	4	9	14	12	*83*	9	19	10	*38*
1887	43	3	4	14	13	*77*	9	19	12	*40*
1892	43	3	4	11	13	*74*	9	19	13	*41*
1897	43	3	4	10	13	*73*	9	19	13	*41*
1902	41	3	4	12	13	*73*	9	10	13	*32*
1907	40	3	4	11	12	*70*	9	9	10	*28*
1912	34	3	4	10	11	*62*	9	9	10	*28*

Notes: The Bavarian statistics begin in 1884.

Source: *Statistik der Knappschaftsvereine des preussischen Staates* und *Statistik der Knappschafts-Vereine im bayerischen Staate*.

Table 2: Summary of main legistlative changes affecting *Knappschaften*

Year	Level of Government	Nature of change
1865	Prussia (Bavaria followed suit in 1865)	Required contributions from firms
1887	*Reich*	Knappschaft becomes part of general sickness and accident insurance system. Most KV have to increase sick payments; new law also requires maximum of 13 weeks sick benefit
1905	*Reich*	Further increases sick pay and doubles maximum benefit to 26 weeks

Table 3: Means, standard deviations, and definitions of main variables

Variable name	**Mean**	**S.D.**	**Definition**
Sick days	7.42	4.54	Number of sick days per KV member
Sick cases	.63	.33	Number of cases of illness per KV member
Sickness length	13.55	6.50	Average number of days for each sick case
Sick pay per sick day	0.95	0.63	Mean sick pay per sick day (Marks)
Firm's portion of costs	0.43	0.11	Portion of all KV costs paid by firms
KV Members	4.06	17.07	Total membership of KV ('000s)
Workers per unit	0.32	0.57	Membership per works ('000s)
Coal production	14.09	11.91	Coal production (defined at regional level) (Millions of Tons)
Firm part per member	22.20	28.57	Total firm contributions to KV, per KV member (Marks)
Rheum	0.10	0.11	Rheumatism cases per KV member
Quet	0.06	0.05	Contusion cases per KV member

Note: Means and standard deviations are pooled across all years and *Knappschaften*.

Table 4: Determinants of the difference between rheumatism and contusions, 1867-1884

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	FE/All KV	FE/Stagnant KV	FE/Dynamic KV	Pooled/All KV	Pooled/Stagnant KV	Pooled/Dynamic KV
Sick pay per sick day	0.182	0.327	0.111	-0.002	-0.092	0.144
	(2.069)	(2.341)	(0.817)	(-0.047)	(-1.427)	(2.000)
Firm's portion of costs	0.043	0.210	0.040	0.102	0.135	-0.029
	(0.717)	(2.014)	(0.417)	(3.024)	(2.197)	(-0.463)
KV Members	-0.005	-0.016	-0.002	-0.001	-0.001	-0.001
	(-0.940)	(-1.394)	(-0.316)	(-2.310)	(-0.313)	(-2.515)
Workers/unit	-0.011	0.019	-0.029	-0.001	-0.003	-0.007
	(-0.596)	(0.577)	(-1.054)	(-0.164)	(-0.182)	(-0.814)
Brown coal	0.008	-0.061	0.046	-0.015	-0.005	0.006
	(0.250)	(-0.993)	(1.140)	(-0.895)	(-0.139)	(0.208)
Hard coal	0.001	0.001	0.002	-0.002	-0.002	-0.002
	(0.424)	(0.167)	(0.597)	(-4.054)	(-0.914)	(-3.458)
Constant	-0.050	-0.177	-0.018	0.019	0.054	-0.003
	(-1.342)	(-1.962)	(-0.432)	(1.303)	(1.175)	(-0.173)
Observations	528	231	297	528	231	297
R-squared				0.166	0.214	0.025
Number of code	56	19	37			

Numbers in parenthesis are t-ratios

Table 5: Evaluation of "difference" model for cause of illness

	Stagnant KVs		Dynamic KVs	
	Fixed-effects model	Pooled model	Fixed-effects model	Pooled model
Elasticities evaluated at the mean:				
Sick pay per sick day	**7.10**	-1.99	2.85	**3.71**
Firm's portion of costs	**2.83**	**1.82**	.63	**-.46**
KV members	-.97	-.04	-.24	-.15
Workers per unit	.17	-.03	-.38	-.09
Brown coal production	-.09	-.01	.06	.08
Hard coal production	.03	-.08	.20	**-.30**

Bold figures correspond to elasticities that are different from zero, in a two-tailed test, at a 95-percent confidence interval

Source: Computed from regressions in Table 4.

Table 6: Determinants of sick days per Knappschaft member

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All Knappschaften			Dynamic KV			Stagnant KV		
	FE	IV	First stage	FE	IV	First stage	FE	IV	First stage
Sick pay per day	-0.761	11.723		-1.453	-2.256		-0.557	220.881	
	(-4.747)	(2.712)		(-4.882)	(-1.240)		(-2.802)	(0.267)	
Firm's portion of costs	3.890	3.463	-0.021	3.549	3.711	0.103	2.804	71.451	-0.289
	(4.191)	(1.902)	(-0.160)	(3.407)	(3.356)	(1.008)	(1.653)	(0.271)	(-0.886)
KV members	0.017	0.074	-0.004	0.019	0.016	-0.004	-1.275	-4.918	0.038
	(2.075)	(2.911)	(-3.414)	(2.540)	(1.447)	(-5.733)	(-6.295)	(-0.316)	(1.078)
Workers per unit	0.615	-0.188	0.071	0.852	0.896	0.059	-0.680	-2.769	0.043
	(3.912)	(-0.454)	(3.362)	(5.757)	(5.031)	(4.252)	(-0.872)	(-0.092)	(0.325)
Coal production	0.007	-0.033	0.008	0.023	0.028	0.010	-0.019	0.895	0.007
	(0.589)	(-1.201)	(6.386)	(1.806)	(1.632)	(9.745)	(-0.687)	(0.251)	(2.248)
1887 and later	0.286	-2.362	0.297	1.060	1.235	0.287	-0.451	-45.309	0.304
	(1.357)	(-2.354)	(13.691)	(4.126)	(2.637)	(16.545)	(-1.303)	(-0.270)	(6.086)
1905 and later	1.538	1.853	-0.007	1.007	1.021	0.043	1.947	13.294	-0.058
	(6.188)	(3.721)	(-0.212)	(3.445)	(3.463)	(1.601)	(4.555)	(0.294)	(-0.779)
Year	0.000	-0.123		-0.020	-0.014		0.049	-3.357	
	(0.034)	(-2.483)		(-1.407)	(-0.700)		(1.942)	(-0.264)	
Firm costs per member			0.004			0.004			0.004
			(4.379)			(6.640)			(1.331)
Constant	6.056	224.892	0.897	45.144	34.019	0.773	-81.197	6,038.186	1.062
	(0.252)	(2.526)	(8.265)	(1.662)	(0.922)	(8.676)	(-1.735)	(0.264)	(4.459)
Observations	2241	2241	2241	1307	1307	1307	934	934	934
Number of groups	78	78	78	48	48	48	30	30	30
Within r-square	.075			.119			.125		
Between “”	.053			.014			.009		
Overall “”	.062			.089			.012		

Note: All models include Knappschaft-level fixed effects and controls for age-structure.

Table 7: Determinants of the number of sick cases

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All Knappschaften			Dynamic Knappschaften			Stagnant Knappschaften		
	FE	IV	First stage	FE	IV	First stage	FE	IV	First stage
Sick pay per day	0.074	0.821		0.073	0.078		0.127	4.546	
	(2.514)	(3.694)		(2.193)	(0.378)		(2.034)	(2.837)	
Firm's portion of costs	0.009	-0.132	-0.021	0.142	0.141	0.103	-0.259	-0.981	-0.289
	(0.088)	(-1.051)	(-0.160)	(1.185)	(1.104)	(1.008)	(-1.358)	(-1.628)	(-0.886)
KV members	-0.000	0.003	-0.004	0.000	0.000	-0.004	-0.098	-0.173	0.038
	(-0.527)	(2.047)	(-3.414)	(0.069)	(0.067)	(-5.733)	(-5.085)	(-2.820)	(1.078)
Workers per unit	0.084	0.034	0.071	0.090	0.089	0.059	0.222	0.055	0.043
	(5.288)	(1.450)	(3.362)	(5.555)	(4.520)	(4.252)	(2.928)	(0.244)	(0.325)
Coal production	-0.002	-0.005	0.008	-0.002	-0.002	0.010	-0.003	0.006	0.007
	(-1.267)	(-2.789)	(6.386)	(-1.110)	(-0.806)	(9.745)	(-0.978)	(0.661)	(2.248)
1887 and later	-0.024	-0.188	0.297	-0.013	-0.014	0.287	-0.042	-0.906	0.304
	(-1.013)	(-3.386)	(13.691)	(-0.436)	(-0.258)	(16.545)	(-1.060)	(-2.737)	(6.086)
1905 and later	-0.097	-0.077	-0.007	-0.170	-0.170	0.043	-0.020	0.125	-0.058
	(-3.594)	(-2.387)	(-0.212)	(-5.050)	(-5.044)	(1.601)	(-0.424)	(0.889)	(-0.779)
Year	-0.003	-0.009		-0.003	-0.003		-0.002	-0.066	
	(-2.027)	(-3.724)		(-1.745)	(-1.331)		(-0.889)	(-2.722)	
Firm costs per members			0.004			0.004			0.004
			(4.379)			(6.640)			(1.331)
Constant	5.843	17.452	0.897	5.706	5.771	0.773	5.647	121.241	1.062
	(2.246)	(3.829)	(8.265)	(1.866)	(1.462)	(8.676)	(1.087)	(2.742)	(4.459)
Observations	1933	1933	2241	1201	1201	1307	732	732	934
Number of code	64	64	78	43	43	48	21	21	30
Within r-square	.060			.079			.102		
Between “”	0			0			.014		
Overall “”	.029			.027			.015		

Note: All models include Knappschaft-level fixed effects and controls for age-structure.

Table 8: Determinants of lengths of illnesses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All *Knappschaften*			Dynamic *Knappschaften*			Stagnant *Knappschaften*		
	FE	IV	First Stage	FE	IV	First Stage	FE	IV	First Stage
Sick pay per day	-4.432	-7.172		-3.574	-7.819		-7.288	-36.944	
	(-7.337)	(-1.811)		(-5.749)	(-1.984)		(-5.111)	(-2.268)	
Firm's portion of costs	5.385	5.902	-0.021	3.877	4.788	0.103	2.933	7.780	-0.289
	(2.563)	(2.637)	(-0.160)	(1.725)	(1.962)	(1.008)	(0.676)	(1.270)	(-0.886)
KV members	0.031	0.019	-0.004	0.040	0.022	-0.004	-0.260	0.240	0.038
	(1.801)	(0.795)	(-3.414)	(2.581)	(0.971)	(-5.733)	(-0.591)	(0.386)	(1.078)
Workers per unit	-0.698	-0.515	0.071	-0.235	0.003	0.059	-6.124	-5.004	0.043
	(-2.133)	(-1.226)	(3.362)	(-0.777)	(0.009)	(4.252)	(-3.552)	(-2.197)	(0.325)
Coal production	0.051	0.063	0.008	0.044	0.072	0.010	0.007	-0.050	0.007
	(1.983)	(2.030)	(6.386)	(1.674)	(1.933)	(9.745)	(0.116)	(-0.563)	(2.248)
1887 and later	0.713	1.313	0.297	0.760	1.715	0.287	0.669	6.472	0.304
	(1.460)	(1.329)	(13.691)	(1.374)	(1.647)	(16.545)	(0.748)	(1.923)	(6.086)
1905 and later	5.484	5.407	-0.007	4.888	4.926	0.043	6.441	5.467	-0.058
	(9.819)	(9.451)	(-0.212)	(7.714)	(7.610)	(1.601)	(6.147)	(3.810)	(-0.779)
Year	0.113	0.137		0.073	0.103		0.248	0.671	
	(3.929)	(3.060)		(2.367)	(2.466)		(3.895)	(2.741)	
Firm costs per member			0.004			0.004			0.004
			(4.379)			(6.640)			(1.331)
Constant	-196.527	-239.124	0.897	-120.225	-172.438	0.773	-448.565	-1,224.411	1.062
	(-3.667)	(-2.942)	(8.265)	(-2.094)	(-2.280)	(8.676)	(-3.788)	(-2.724)	(4.459)
Observations	1933	1933	2241	1201	1201	1307	732	732	934
Number of groups	64	64	78	43	43	48	21	21	30
Within r-square	.183			.175			.256		
Between “”	.003			.040			.006		
Overall “”	.086			.103			.121		

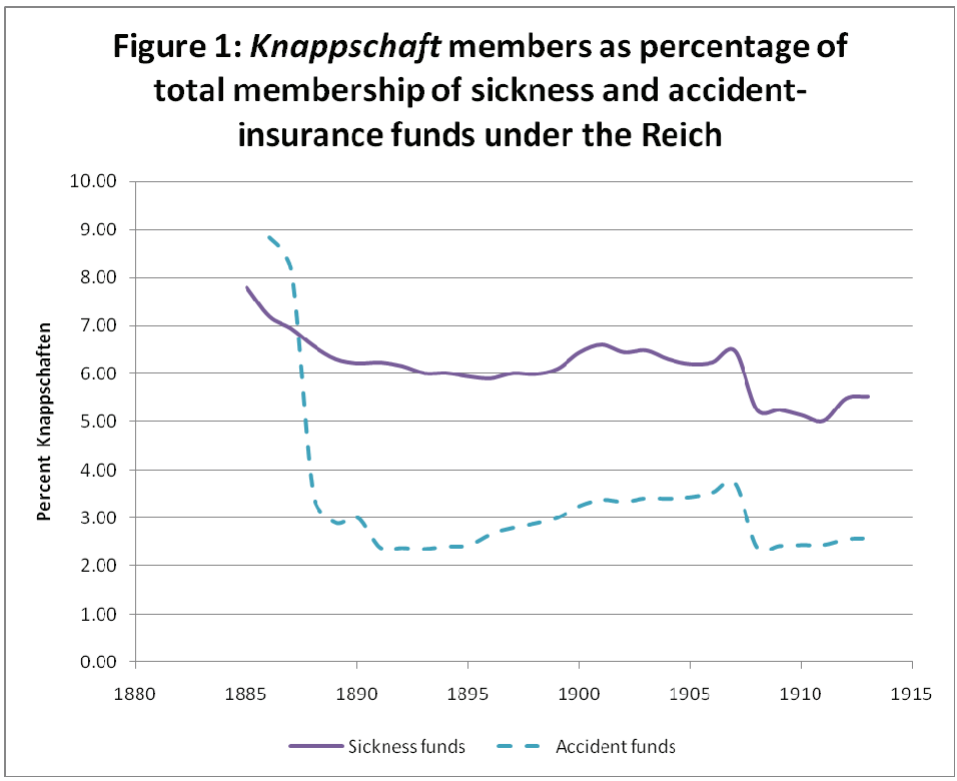
Note: All models include Knappschaft-level fixed effects and controls for age-structure.

Table 9: Summary of Moral Hazard Effects

	Sick days per member	Sick cases per KV member	Sick days per case of illness
Sick pay	-.276	.109	-.507
Firm share of costs	**.213**	.094	**.148**
Total KV membership	.020	.001	.016
Members/works	**.047**	**.056**	0
Coal production	.055	0.036	.077
1887 and later	**.066**	-.009	.054
1905 and later	**.085**	**-.016**	**0.022**

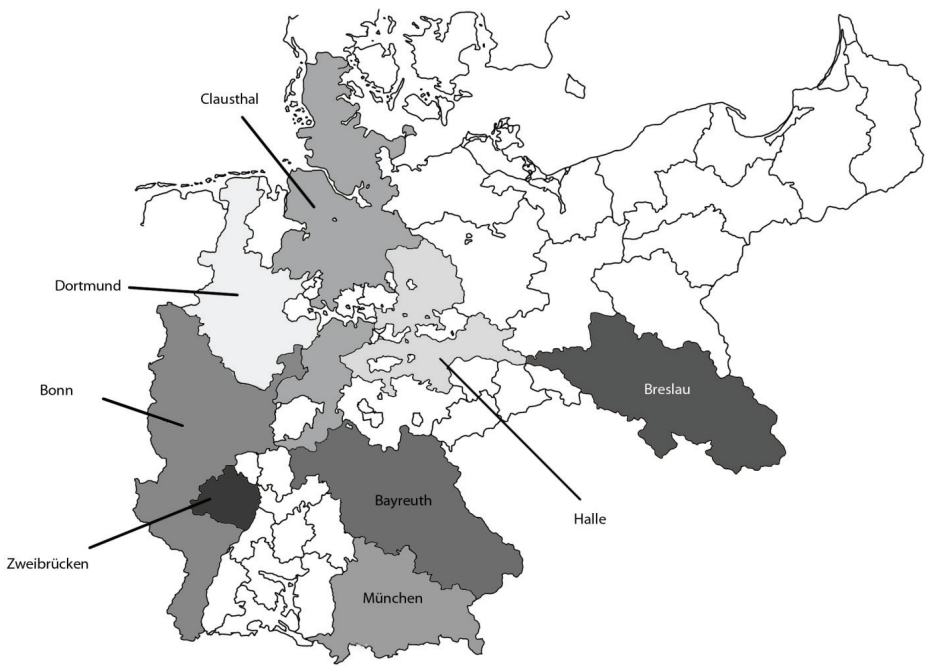
Source: IV regressions for "dynamic" KV reported in tables 6-8.

Note: Figures reported are elasticities evaluated at the mean. Figures in bold are associated with a t-ratio greater than 1.9



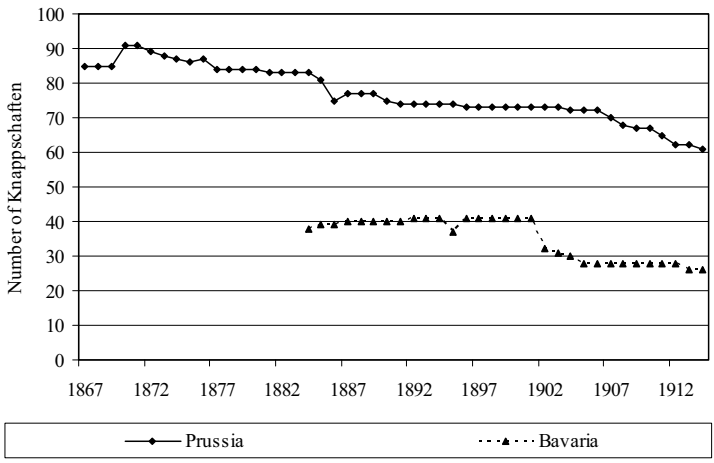
Sources: Social insurance data for 1885 to 1913 are from David Khoudour-Castéras (2008), "Welfare State and Labor Mobility: The Impact of Bismarck's Social Legislation on German Emigration before World War I,"*Journal of Economic History*, 68(1), 211-243, and from Johannes Frerich and Martin Frey (1993), *Handbuch der Geschichte der Sozialpolitik in Deutschland: Von der industriellen Zeit bis zum Ende des Dritten Reiches (Bd. 1)*, München/Wien, pp. 102-106; *Knappschaft* data are from the *Statistik der Knappschaftsvereine des preussischen Staates* as detailed in Appendix A.

Figure 2: Locator map of the mining administration regions (*Oberbergamtsbezirken*)



***Note*: White areas are those lacking mines or outside the mining regions administered by Prussia and Bavaria. We refer to the districts by the name of the city from which the district was administered.**

Figure 3: Number of Knappschaften, Prussia and Bavaria, 1867-1914



Source: *Statistik der Knappschaftsvereine des Preussischen Staates* and *Statistik der Knappschaftsvereine im bayerischen Staate*.

Figure 4: Rheumatism and contusions, 1867-1884

Unweighted means of reports per member

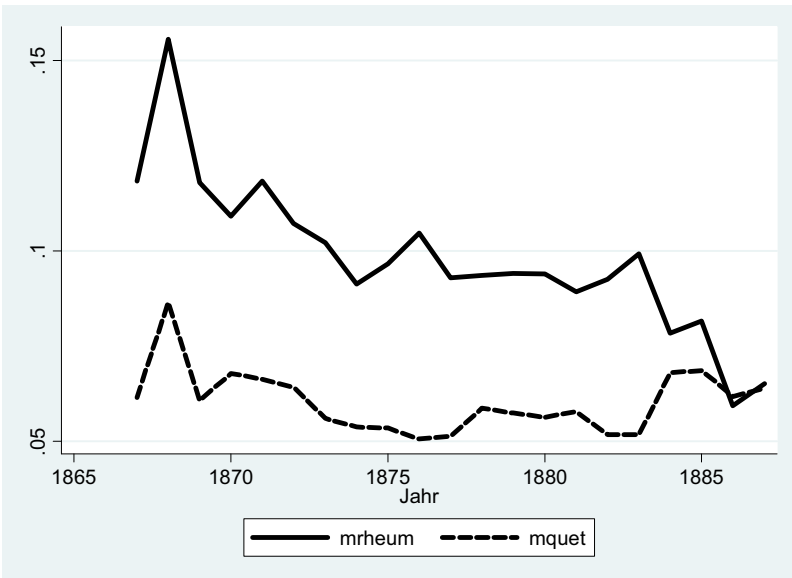
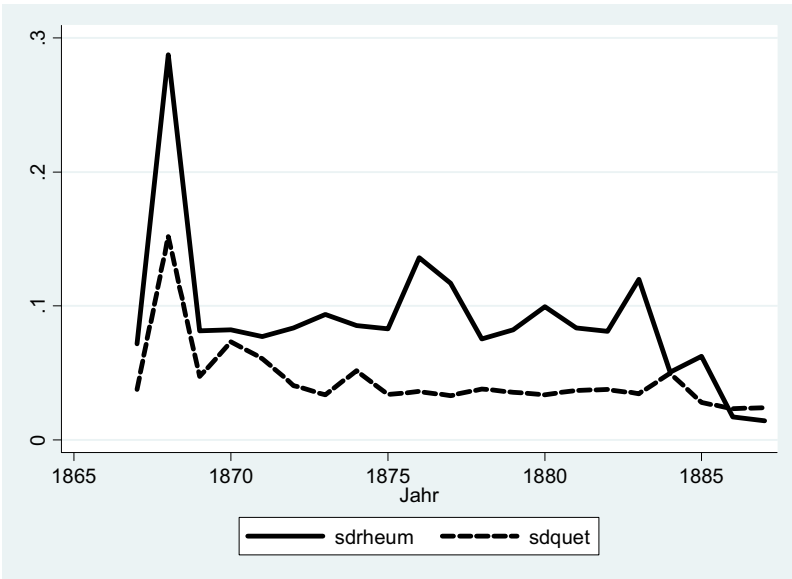


Figure 5: Standard deviations of rheumatism and contusions

Unweighted



Appendix A: Data sources

A. Preußen

(1) Statistik der Knappschaftsvereine des Preussischen Staates
(erschienen in: Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate, Ministerium für öffentliche Arbeiten/ Ministerium für Handel und Gewerbe, Jg. 16-56, 1868-1908)

(2) Statistik der Krankheitsfälle der activen Knappschaftsmitglieder im Preussischen Staate
(erschienen in: Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate, Ministerium für öffentliche Arbeiten, Jg. 16-36, 1868-1888)

(3) Fischer, Wolfram (Hrsg.), Statistik der Bergbauproduktion Deutschlands 1850-1914, Quellen und Forschungen zur historischen Statistik von Deutschland VIII, St. Katharinen, 1989

Variable	Beobachtungszeitraum	Quelle
Anzahl der - Bergwerke und Aufbereitungsanstalten (Steinkohlen, Braunkohlen, Eisenerz, sonstige Erze, Steinsalz, Steinbrüche), - Hüttenwerke und zugehörigen Werkstätten (Eisen und Stahl, Zink, Blei/ Kupfer/Silber, Alaun/Vitriol, Teer/ Paraffin), - Salinen je Knappschaftsverein und Oberbergamtsbezirk[i]	1867-1907	(1) Tabelle I. B.
Art der Krankheitsfälle, - Gelenkrheumatismus, - Parasiten, - Quetschungen und Contusionen, - Rheumatismus, - Wunden, - Wurmkrankheit, je Knappschaftsverein	1867-1887	(2)
Ausgaben für Arzthonorare je Knappschaftsverein[ii]	1867-1907	(1) Tab. V. D.
Ausgaben für Krankenlöhne je Knappschaftsverein	1867-1907	(1) Tab. V. D.
Ausgaben für Medizin je Knappschaftsverein	1867-1907	(1) Tab. V. D.
Ausgaben der Krankenkasse für Arzthonorare (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1907	(1) Tab. V. D.
Ausgaben der Krankenkassen für Krankenlöhne (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1907	(1) Tab. V. D.

Variable	Beobachtungszeitraum	Quelle
Ausgaben der Krankenkassen für Medizin (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1907	(1) Tab. V. D.
Bezahlte Krankheitstage der ständigen Mitglieder je Knappschaftsverein	1867-1888	(1) Tab. IV.
Bezahlte Krankheitstage der unständigen Mitglieder je Knappschaftsverein	1867-1888	(1) Tab. IV.
Bezahlte Krankheitstage je Knappschaftsverein	1867-1907	(1) Tab. IV.
Durchschnittliche Krankheitstage pro Krankheitsfall bei ständigen Mitgliedern je Knappschaftsverein	1867-1888	(1) Tab. IV.
Durchschnittliche Krankheitstage pro Krankheitsfall bei unständigen Mitgliedern je Knappschaftsverein	1867-1888	(1) Tab. IV.
Durchschnittliche Krankheitstage pro Krankheitsfall je Knappschaftsverein	1867-1888	(1) Tab. IV.
Förderung von Braunkohle		
- Deutsches Zollgebiet und Königreich Preußen	1850-1914	(3) Tab. 60-61
- OBAB Bonn, Breslau, Clausthal, Dortmund und Halle	1861-1914	(3) Tab. 112-116
Förderung von Steinkohle		
- Deutsches Zollgebiet und Königreich Preußen	1850-1914	(3) Tab. 1-2
- OBAB Bonn, Breslau, Clausthal und Dortmund und Halle	1861-1914	(3) Tab. 43 bis 47
Gesamtausgaben der Krankenkassen (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1907	(1) Tab. V. D.
Gesamteinnahmen der Krankenkassen (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1907	(1) Tab. V. C.
Gesundheitsausgaben je Knappschaftsverein	1867-1907	(1) Tab. V. D.
Kranke ständige Mitglieder je Knappschaftsverein am 01. Januar des Jahres	1867-1888	(1) Tab. IV.
Kranke ständige Mitglieder je Knappschaftsverein am 31. Dezember des Jahres	1867-1888	(1) Tab. IV.
Kranke unständige Mitglieder je Knappschaftsverein am 01. Januar des Jahres	1867-1888	(1) Tab. IV.
Kranke unständige Mitglieder je Knappschaftsverein am 31. Dezember des Jahres	1867-1888	(1) Tab. IV.
Krankenabgänge durch Tod je Knappschaftsverein	1867-1907	(1) Tab. IV.
Krankenabgänge durch Genesung je Knappschaftsverein	1867-1907	(1) Tab. IV.
Krankenabgänge wegen anderer Ursachen je Knappschaftsverein	1867-1907	(1) Tab. IV.

Variable	Beobachtungszeitraum	Quelle
Ständige Mitglieder je Knappschaftsverein und Altersklasse am 31. Dezember des Jahres - unter 16 Jahren, - zwischen 16 bis 25 Jahren, - zwischen 26 bis 35 Jahren, - zwischen 36 bis 45 Jahren, - zwischen 46 bis 55 Jahren, - über 56 Jahren, bzw. - unter 16 Jahren, - zwischen 16 bis 20 Jahren, - 21- bis 25-Jährige, - 26- bis 30-Jährige, - 31- bis 35-Jährige, - 36- bis 40-Jährige, - 41- bis 45-Jährige, - 46- bis 50-Jährige, - 51- bis 55-Jährige, - über 56 Jahre,	1867-1888 1889-1907	(1) Tab. II.
Summe aller Arbeitsunfälle je Knappschaftsverein (im Lazarett und zuhause behandelt)	1867-1907	(1) Tab. IV.
Summe aller sonstigen Krankheitsfälle je Knappschaftsverein	1867-1907	(1) Tab. IV.
Summe aller kranken Mitglieder (ständige und unständige) je Knappschaftsverein am 01. Januar des Jahres	1867-1907	(1) Tab. IV.
Summe aller kranken Mitglieder (ständige und unständige) je Knappschaftsverein am 31. Dezember des Jahres	1867-1907	(1) Tab. IV.
Summe aller Krankheitsfälle je Knappschaftsverein auf Grund Quetschungen und Wunden	1867-1887	(2)
Summe aller Krankheitsfälle je Knappschaftsverein auf Grund von Rheumatismus	1867-1887	(2)
Summe aller Krankheitsfälle je Knappschaftsverein auf Grund von Parasiten und der Wurmkrankheit	1867-1887	(2)
Summe der Mitgliedsbeiträge der Ständigen zur Krankenkasse je Knappschaftsverein (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1888	Tab. V. C
Summe der Mitgliedsbeiträge der Unständigen zur Krankenkasse je Knappschaftsverein (einige Knappschaftsvereine in den OBABs Bonn, Clausthal und Halle)	1867-1888	Tab. V. C
Summe aller Beiträge der Werkseigentümer zur Krankenkasse je Knappschaftsverein (einige Knappschaftsvereine in den OBAB Bonn, Clausthal und Halle)	1867-1907	Tab. V. C
Summe aller Mitgliedsbeiträge zur Krankenkasse je Knappschaftsverein (einige Knappschaftsvereine in den OBABsBonn, Clausthal und Halle)	1867-1907	Tab. V. C
Summe der Mitgliedsbeiträge der Ständigen je Knappschaftsverein	1867-1888	Tab. V. C.

Variable	Beobachtungszeitraum	Quelle
Summe der Mitgliedsbeiträge der Unständigen je Knappschaftsverein	1867-1907	Tab. V. C.
Summe aller Mitgliedsbeiträge je Knappschaftsvereins	1867-1907	Tab. V. C.
Summe aller Beiträge der Werkseigentümer je Knappschaftsverein	1867-1907	Tab. V. C.
Summe der ständigen Mitglieder je Knappschaftsverein am 01. Januar des Jahres	1867-1907	Tab. II.
Summe der ständigen Mitglieder je Knappschaftsverein am 31. Dezember des Jahres	1867-1907	Tab. II.
Summe der unständigen Mitglieder je Knappschaftsverein am 01. Januar des Jahres	1867-1907	Tab. II.
Summe der unständigen Mitglieder je Knappschaftsverein am 31. Dezember des Jahres	1867-1907	Tab. II.
Zahl der Arbeitsunfälle je Knappschaftsverein, im Lazarett behandelt	1867-1907	Tab. IV.
Zahl der Arbeitsunfälle je Knappschaftsverein, zuhause behandelt	1867-1907	Tab. IV.
Zahl der sonstigen Krankheitsfälle je Knappschaftsverein, im Lazarett behandelt	1867-1907	Tab. IV.
Zahl der sonstigen Krankheitsfälle je Knappschaftsverein, zuhause behandelt	1867-1907	Tab. IV.

[i] Oberbergamtsbezirke (OBABs) im Königreich Preußen: Bonn, Breslau, Clausthal, Dortmund, Halle.

[ii] Sämtliche Geldgrößen werden in der preußischen Knappschaftsstatistik bis 1874 einschließlich in preußischen Talern (14-Taler-Fuß) und Silbergroschen angegeben, ab 1875 in Mark und Pfennig. Die Umrechnung von Talern (Silbergroschen) in Mark (Pfennige) erfolgt zu 1 Taler gleich 3 Mark (30 Silbergroschen gleich 100 Pfennige); Quelle: Sprenger, Bernd, Das Geld der Deutschen – Geldgeschichte Deutschlands von den Anfängen bis zur Gegenwart, Paderborn et al., 1991, S. 187.

Appendix A, continued

A. Bayern

(1) Statistik der Knappschaftsvereine im bayerischen Staate (Königlich Bayerisches Oberbergamt, Jg. 14-37, 1884-1907)
(2) Fischer, Wolfram (Hrsg.), Statistik der Bergbauproduktion Deutschlands 1850-1914, Quellen und Forschungen zur historischen Statistik von Deutschland VIII, St. Katharinen, 1989

Variable	Beobachtungszeitraum	Quelle
Anzahl der - Bergwerke und Aufbereitungsanstalten (Steinkohlen, Braunkohlen, Eisenerz, sonstige Erze, Steinsalz, Steinbrüche), - Hüttenwerke und zugehörigen Werkstätten (Eisen und Stahl, Zink, Blei/ Kupfer/Silber, Alaun/Vitriol, Teer/ Paraffin), - Salinen je Knappschaftsverein und Berginspektionsbezirk, Bayern 1884-1907[ii]	1884-1907	(1) Tabelle I. B.
Ausgaben für Arzthonorare je Knappschaftsverein[ii]	1884-1907	(1) Tab. V. D.
Ausgaben für Krankenlöhne je Knappschaftsverein	1884-1907	(1) Tab. V. D.
Ausgaben für Medizin je Knappschaftsverein	1884-1907	(1) Tab. V. D.
Bezahlte Krankheitstage je Knappschaftsverein	1884-1907	(1) Tab. IV.
Durchschnittliche Krankheitstage pro Krankheitsfall je Knappschaftsverein	1884-1907	(1) Tab. IV.
Förderung von Braunkohle im Königreich Bayern	1860-1914	(2) Tab. 112-119
Förderung von Steinkohle im Königreich Bayern	1850-1914	(2) 48 und 50
Gesamtausgaben der Krankenkassen	1901-1907	(1) Tab. V. D.
Gesamteinnahmen der Krankenkassen	1901-1907	(1) Tab. V. C.
Gesundheitsausgaben je Knappschaftsverein	1884-1907	(1) Tab. V. D.
Krankenabgänge durch Tod je Knappschaftsverein	1884-1907	(1) Tab. IV.
Krankenabgänge durch Genesung je Knappschaftsverein	1884-1907	(1) Tab. IV.
Krankenabgänge wegen anderer Ursachen je Knappschaftsverein	1884-1907	(1) Tab. IV.

Variable	Beobachtungszeitraum	Quelle
Ständige Mitglieder je Knappschaftsverein und Altersklasse am 31. Dezember des Jahres - unter 26 Jahren - 26- bis 35-Jährige - 36- bis 45-Jährige - 46- bis 55-Jährige - 56- bis 65-Jährige	1884-1907	(1) Tab. II.
Summe aller Krankheitsfälle je Knappschaftsverein	1884-1907	(1) Tab. IV.
Summe aller Krankheitsfälle je Knappschaftsverein	1884-1907	(1) Tab. IV.
Summe aller kranken Mitglieder (ständige und unständige) je Knappschaftsverein am 01. Januar des Jahres	1884-1907	(1) Tab. IV.
Summe aller kranken Mitglieder (ständige und unständige) je Knappschaftsverein am 31. Dezember des Jahres	1884-1907	(1) Tab. IV.
Summe aller Beiträge der Werkseigentümer zur Krankenkasse je Knappschaftsverein	1901-1907	(1) Tab. V.
Summe aller Mitgliedsbeiträge zur Krankenkasse je Knappschaftsverein	1901-1907	(1) Tab. V.
Summe aller Mitgliedsbeiträge je Knappschaftsverein	1884-1888	(1) Tab. V.
Summe der ständigen Mitglieder je Knappschaftsverein am 01. Januar des Jahres	1884-1907	(1) Tab. II.
Summe der ständigen Mitglieder je Knappschaftsverein am 31. Dezember des Jahres	1884-1907	(1) Tab. II.
Summe der unständigen Mitglieder je Knappschaftsverein am 01. Januar des Jahres	1884-1907	(1) Tab. II.
Summe der unständigen Mitglieder je Knappschaftsverein am 31. Dezember des Jahres	1884-1907	(1) Tab. II.