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Incentives that Saved Lives: Government Regulation of Accident Insurance Associations in Germany, 1884-1914

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Incentives that saved lives: Government regulation of accident insurance associations in Germany, 1884-1914

Timothy Guinnane and Jochen Streb

Abstract

The German government introduced compulsory accident insurance for industrial firms in 1884. This insurance scheme was one of the main pillars of Bismarck's famous social insurance system. The accident-insurance system achieved only one of its intended goals: it successfully compensated workers and their survivors for losses due to accidents. The accident-insurance system was less successful in limiting the growth of work-related accidents, although that goal had been a reason for the system's creation. We trace the failure to stem the growth of accidents to faulty incentives built into the 1884 legislation. The law created mutual insurance groups that used an experience-rating system that stressed group rather than firm experience, leaving firms with little hope of saving on insurance contributions by improving the safety of their own plants. The government regulator increasingly stressed the imposition of safety rules that would force all firms to adopt certain safety practices. Econometric analysis shows that even the flawed tools available to the insurance groups were powerful, and that more consistent use would have reduced industrial accidents earlier and more extensively.

JEL codes: N33, G22, and H55.

Keywords: Social insurance, accident insurance, workman's compensation, regulation

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The compulsory accident insurance system introduced in 1884 formed the second pillar of Bismarck's system of social insurance. (The first pillar was health insurance, introduced in 1883). Advocates had two goals. They wanted to shield workers and firms from the economic consequences of industrial accidents. They also aimed to create the right institutional mechanism for a sustained struggle against a rising toll of industrial accidents. By mandating payments and creating large, financially solid insurance carriers, the new system met the first goal admirably. The new system also contained features that should have encouraged firms to adopt the latest methods to make their factories safer. On its face, the new system did not achieve this second goal; in 1914, there were 9.7 accidents per thousand covered workers in all, more than double the rate when the system was first introduced. Some individual sectors did much worse. The construction industry had 18.1 accidents per thousand workers in 1914, with a lethal accident rate of about 1.5 per thousand, again much increased from the 1880s.[1]

There were a few bright spots, however. In some especially dangerous sectors, such as steel production, the overall accident rate began to decline in the years prior to 1914. The steel industry's experience also hints at a more general pattern: while the overall accident rate in many industries did not decline as much as hoped, this overall accident rate combined a decline in fatal accident rates coupled with an increase in the rate of accidents with less serious consequences. Our findings suggest this experience could have been more general.

Bismarck's system was based on a new, special-purpose mutual enterprise called a *Berufsgenossenschaft* (hereafter BGS). The BGS was a mutual insurance carrier for firms in related industries. Each BGS had a great deal of autonomy, subject only to some mandated approvals and additional rulings from the *Reichsversicherungsamt* (hereafter RVA), the Imperial Insurance Office. The system had two elements that would seem to provide the BGS with the means to reduce accidents. First, each firm paid an insurance contribution that was partly experience-rated. Second, the BGS could also issue rules governing safety practices (*Unfallverhütungsvorschriften*) in the factories run by its member

[1] These figures are from the "BGS database" which consists of annual observations on all accident-insurance carriers from 1885 through 1914. We provide more detail and sources for this database in the appendix.

firms, and appoint inspectors to make sure the rules were followed. A BGS could also fine firms that did not comply with is rules.

The fact that rules were seen as useful suggests that the incentives implicit in the insurance contributions worked at best imperfectly. One can justify the RVA's stress on rules in two different ways. First, the RVA was in a position to study safety practices and to nudge firms to adopt methods that had worked elsewhere. Production managers concerned about day-to-day operations have little time for opened-ended inquiry, and the RVA's efforts here amounted to reducing the cost of research for firms. Second, the RVA emphasis on rules can be seen in the context of Weitzman (1974)'s famous discussion of prices (P) and quantities (Q). In theory a BGS could achieve the desired (presumably lower) rate of accidents by announcing the correct P, that is, the premium depending on its number of accidents, and letting firms optimize in the face of that constraint. If P is indeed announced correctly, and there are no externalities or information problems, the BGS could achieve its ends without any rules. As we show, however, the system introduced externalities that made the "price" approach at best imperfect. Thus, the RVA concluded, to achieve accident reductions, the BGS would have to fix Q, that is, introduce rules that required firms to adhere to certain practices. As Weitzman stresses, in general there is no particular reason to prefer the P approach over the Q approach. Here P did not work perfectly because of the way the system was designed.

Throughout we focus on the specific problem of controlling industrial accidents in the German Reich. But the themes raised here relate to two other literatures. First, Bismarck's social insurance system was arguably the first in the world. Admirers have long stressed its successful combination of services and cost control. Bismarck's insurance scheme formed the institutional model for the current systems in Germany and several other Continental countries, and long functioned as the *desideratum* for U.S. and other reformers. As I. Rubinow wrote in 1913, "There is no doubt that the modern conception of social insurance – as a system carrying with it compulsion, state subsidies, and strict state supervision and control – has reached its highest development in modern Germany, so that any system embodying, to any large degree, all these three elements, maybe described as the German system."[2] Here we stress features of the system that did not work as well, as acknowledged even by sympathetic contemporaries. Second, the broader question of how to motivate individual behavior in a mutual system lies at the heart of a great deal of research in insurance, finance, and related fields. Our story suggests that the BGS never fully overcame the free-riding problem that plagues many mutual schemes.

This paper is part of a larger study of the development of social insurance in Germany. A series of earlier papers (Guinnane and Streb (2011), Jopp (2010-2012)) focused on the *Knappschaften*, the older miner's insurance system whose practices were influential in the formation of Bismarck's social insurance scheme. The current paper draws on both the published statistics of the BGS and the RVA, and the archival material from the RVA located in the federal archives in Berlin.

1. From Liability Legislation to Accident Insurance

The 1884 accident-insurance legislation reflects dissatisfaction with earlier approaches. In the 1860s industrial accidents became the subject of extensive discussion. The political historiography rightly stresses industrial accidents and the later accident-insurance system as part of a broader struggle that first saw attempts to suppress the worker's movement, and later efforts to co-opt at least parts of it. Labor groups argued that industrial accidents reflected the abuse of workers by the capitalist system; firms could save money by not making safety improvements, instead letting workers bear the human and financial consequences of injury and death. Military and other leaders worried that industrial accidents were killing and maiming the potential soldiers necessary to protect Germany. And a wide range of observers complained that the cost of industrial accidents fell on taxpayers through the local poor law. Firms provided a relatively small share of the taxes that supported the poor relief system, so observers felt the

[2] Rubinow (1913 [1969], p.13). The point of the longer passage is to deny Bismarck's central role in the creation of modern social insurance; Rubinow asserts what is now the received view that the "new" German social insurance system rested on earlier institutions, and that experimentation in other countries had also produced useful results. Isaac Max Rubinow worked as a physician and actuary, and was influential in the U.S. Progressive circles.

industrial firms were shifting the consequences of a poor safety record to local taxpayers, many of whom benefited little, if at all, from the presence of industrial firms.

The well-documented rising tide of industrial accidents formed the backdrop to these discussions. A series of accidents in the late 1860s seemed intended to illustrate these problems. In 1867, a shaft in the Saxon Lugnau coal mine collapsed, claiming 101 victims. Methane gas explosions at the Ruhr mine "Neu-Iserlohn" killed a total of 99 miners in 1869. Later that year, gas explosions in the Saxon mines *Segen Gottes* ("God's Blessing") and *Neue Hoffnung* ("New Hope") killed a further 340 miners (Kleeberg (2003, p. 86 ff)). The local *Knappschaften* (a mutual-insurance system operating for miners only) paid for medical expenses and disability pensions, but the latter were perceived as inadequate (Boyer 1995, p.21). Outside the mining industry there was no comparable system of social protection. Public opinion was particularly offended that the surviving relatives of the victims were not entitled to compensation from the employer. They could only hope for support from poor relief.[3]

In response to these problems the government introduced the Imperial Liability Act of 7 June 1871, which in theory made firms financially responsible for the consequences of accidents. The way it assigned responsibility however, made the law at best a partial success. Strict liability applied only to railways (Kleeberg (2003), Held (1888)). For other sectors the law placed a burden of proof on the injured worker. Operators of mines, quarries, or factories were obliged to compensate accident victims or their survivors only if the worker or his representative could prove that the owners had caused the accident by their own acts or omissions. Labor groups opposed the 1871 Act, arguing that because of their limited education and financial reserves, working people were not in a position to pursue legal action against their employers, even if likely to win eventually. As the provincial Government in Düsseldorf put it in 1877

> The factory inspector's report notes that the effects of the Liability Act do not correspond to expectations. At best, only the accident insurance companies have benefited. The insurer and especially the worker are seldom able to provide the proof of liability that §2 of the Act requires. The fact that the injured has the burden of proof means that the law is illusory in most cases. The injured man has neither the ability nor the means to drag the factory owners into a lengthy court case. For this

[3] On *Knappschaften* see Guinnane and Streb (2011) as well as Guinnane, Jopp, and Streb (2012). For a discussion of these accidents see *Kongress deutscher Volkswirte* (1869).

> reason court cases are exceedingly rare, in most cases there is a meager monetary agreement, and often the injured walks away completely empty-handed.[4]

Many employers purchased liability insurance to meet potential costs under the Act. Contemporaries claimed these insurance policies exacerbated the problem because insurance companies had a greater interest in and expertise at avoiding or delaying payments (see, for example, *Norddeutsche Allgemeine Zeitung* 1882).[5] The liability legislation left employers equally unhappy. Many complained that judges were too willing to rule in favor of an injured worker, and often assigned unreasonable damages (Lehr (1888, pp.27-39)). According to Baare, the Director General of the Bochum Association of Mining and Cast Steel, this situation led many accident victims to gamble on a big win in court: "If the worker wins, he becomes a pensioner; if he loses, he becomes a beggar." [6]

The situation prevailing in Germany under the 1871 liability echoes problems that arose in Anglo-Saxon countries under common-law doctrines of liability. Part of the issue in England and the United States turned on the ways common-law rules were interpreted; in some jurisdictions, judges absolved employers of responsibility if they found that either the worker himself or some other agent (potentially another worker) bore some fault. Historians have also stressed the practical difficulties facing workers who tried to sue their employers under common-law rules. An injured worker (or his survivor) was usually not in a position to finance litigation and wait for a court decision that might take years. And potential witnesses might be reluctant to testify in a workers' favor, since there were most likely employees of the same firm as the injured worker, and could be fired.[7]

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[4] Bericht der Regierung Düsseldorf an den preußischen Handelsminister Dr. Heinrich Achenbach, 2. August 1877, in: Born et al (1993), 54. All translations from German are our own.

[5] Little is known about the liability insurance industry that covered firms in the period 1871-1884. Apparently many of the first employers in the new BGS were former employees of insurance companies who had been let go when the 1884 law reduced demand for their product. The RVA attributed the success in starting the 1884 system quickly to the experience and availability of these employees (Geschäftsbericht des RVA für die Zeit bis zum 31. Dezember 1885, BArch R89/491).

[6] Promemoria des Kommerzienrats Louis Baare für den preußischen Handelsminister Karl Hofmann, 30. April 1880, in: Born et al (1993), 163.

[7] The best reference on "workman's compensation" in the United States is Fishback and Kantor (2000). Witt (2004) traces the evolution of U.S. law on employer liability.See also Glaeser and Shleifer (2003).

The 1884 Act

Like the rest of Bismarck's social-insurance system, the 1884 accident-insurance law described a class of workers who were required to participate in the scheme. The accident insurance law (§1) at first included all employees with an annual income of up to 2000 Marks who worked in mines, saltworks, processing plants, quarries, shipyards, factories and steel mills. Later legislation expanded the compulsory insurance to other occupations/groups such as agricultural workers and construction workers.[8] In 1885, the first year for which comprehensive data are available, the system insured almost three million workers. By 1914, through the extension of the system to new industries and the growth of industries already covered, that figure had grown to 9.2 million workers.

Both workers and factory owners welcomed the shift to insurance with the 1884 Act. Labor groups preferred the insurance approach partly because it removed the question of "fault" from the compensation discussion. Thus the 1884 system was a form of strict liability where the pay-outs were capped. The owners also preferred accident insurance to the older liability scheme. Insurance made accident costs limited and calculable both by assigning specific tariffs to particular types of outcomes, and by pooling costs across a large number of firms and thus making insurance costs stable (Wickenhagen (1980), Bödiker (1895)).

The 1884 law forbad private-law claims against employers, so the insurance premia were the only costs to employers (Clemens (1889)). These restrictions seem indeed to have reduced expenses per accident. According to Lehr's calculations, expenses per accident for one of the BGS in 1886 were about 182 Marks. In 1882, the damages covered by the private accident insurer Leipziger Unfallbank amounted to more than 500 Marks per accident (Lehr 1888).[9] Workers made no direct contribution to the BGS. But

[8] See *Gesetz über die Ausdehnung der Unfall- und Krankenversicherung (May 28 1885); Gesetz, betreffend die Fürsorge für Beamte und Personen des Soldatenstands in Folge von Betriebsunfällen (March 1886); Gesetz betreffend die Unfall- und Krankenversicherung der in land- und forstwirtschaftlichen Betrieben beschäftigten Personen (May 5 1886); Gesetz, betreffend die Unfallversicherung der bei Bauten beschäftigten Personen (July 11 1887); and Gesetz, betreffend die Unfallversicherung der Seeleute und anderer bei der Seeschifffahrt beteiligten Personen (July 13 1887*).

[9] Fishback and Kantor (2000) and Fishback (1987) note that the average compensation to accident victims in the U.S. rose when states introduced workman's compensation laws. But in the U.S., many injured workers had

workers still bore some of the costs; for the first thirteen weeks after an accident, medical costs were shouldered by the worker's health-insurance fund, and workers paid half the costs of their health insurance (§5).[10] The 1884 law (§5) required that an injured worker receive all necessary medical care free of charge. The law also specified a menu of mandatory additional benefits based on the worker's income at the time of the accident. A permanently disabled worker, for example, received 66.6 percent of his last earnings as a pension; a worker's widow was entitled to twenty percent of her husband's last labor earnings (until she remarried); and each surviving child of worker killed in an accident received fifteen percent of the worker's earnings until the age of 15.[11] Thus while instituting a form of strict liability, the 1884 Act capped damages.

The institutional heart of the accident insurance system was the BGS.[12] §9 of the 1884 Act designated the BGSs as the carrier of accident insurance. Each BGS consisted of a group of firms in related industries. The law allowed companies to create either a single, nation-wide organization, or to form regional groupings within a single industry. Both types of BGS emerged. All German musical-instrument makers belonged to a single BGS, for example. The iron and steel industry, on the other hand, established eight regional BGS. The BGS paid all costs for therapies, accident benefits and administrative costs, and funded these expenses by levying contributions on member firms (§10). This paper focuses on the operation of the accident-insurance system, and thus defers the political economy of its creation to a later point in the project. Yet the system's design may reflect its origins in ways that affected its performance.

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previously received little or no compensation. The reduction in average compensation in Germany after the 1884 Act suggests that insured German firms had had to compensate most accident victims before. Unfortunately we have no information on this earlier period and thus cannot compare compensation levels before and after the 1884 Act.

[10] A BGS could provide for the injured through special rehabilitation programs during this waiting period to restore their ability to work and to avoid permanent accident benefits. "It was emphasized that in cases of serious injury, the restoration of the working ability of the injured was usually quicker and more sustainable in cases where an immediate, even if expensive, treatment program followed the injury rather than relying on health insurance treatment… In this way not only the interests of the injured were served, but the substantial expenses of the BGS were decreased by a lessening of permanent benefit payments." Umfrage betreffend die Übernahme des Heilverfahrens während der Karenzzeit durch die Berufsgenossenschaften gemäß §76c des Krankenversicherungsgesetzes, March 1895, BArch R 89/630.

[11] All widow and orphan benefits together could not exceed sixty percent of the worker's last wages.

[12] Although called „cooperatives" (*Genossenschaften*), these entities bore no legal or other relationship to the older system of cooperatives that provided credit and other services to farmers and small producers in Germany. See Guinnane (2001).

Clearly the system came into being because it received the support of most actors with a stake in the legislation.[13] But that does not mean that all actors favored the system as it came into being. Mares (2003) argues that some high-risk producers (such as iron and steel) had wanted a national system that would allow them to shift some of their costs to safer sectors (such as textiles). The BGS system made such cost-shifting *across sectors* impossible. But the system clearly tolerated cost-shifting *within* BGS, perhaps from large to small firms. Under §14 of the 1884 Act, larger firms received more votes for the governing bodies of the BGS. Voting rules were not linear, but a firm with 20 covered worked had one vote, a firm with 1000 workers had 18 votes, and a firm with 10,000 covered workers had 108 votes. Thus it was possible for a small number of large firms to outvote smaller firms within the BGS, and this power would enable them to adopt procedures that would penalize small firms relative to their actual risks. We cannot test this claim with the information currently available, however, so it remains a possible explanation for findings reported below.[14]

Table 1 provides a statistical overview of the 68 BGS that existed in 1914. The RVA organized them into 26 different sectors. The size of the average BGS differed considerably across sectors, from the huge organizations in construction, mining and iron and steel down to the small groups for insurance and musical instruments. More importantly, the reported accident rates in 1914 differed dramatically. A railroad worker was 6.6 times as likely to suffer a fatal accident, and 5.3 times as likely to meet with any accident, as a worker in the insurance industry in that year. For inland water transport the death rate was even higher.

2. Allocating costs

[13] Fishback and Kantor argue the same for the United States; workmen's compensation systems pleased both labor and employer interests, and thus were enacted at the same time as other elements of a social-insurance system went down to defeat. This was clearly not the case in Germany, but, given the limited democratic accountability of the Reich government, it is unclear whether Bismarck's success in creating a general social-insurance system can be taken as evidence that German interests supported health insurance and other measures.

[14] To this point we have been unable to use any archival information for the BGS in the period prior to World War I. The archive consulted for this project is for the RVA. Presumably the BGS's internal records would enable us to study some of the questions left unanswered in the present paper. We continue to pursue archival material for our project.

Perhaps the BGS's most important task (§28) was to allocate the costs of accidents across member firms. To do this, the BGS constructed a risk estimate that supposedly reflected each firm's contribution to expected costs. (We will refer to the entire scheme as the "tariff," and the individual risk figure assigned to each firm as its "risk level.") Each BGS was required to construct a tariff intended to last for 3-5 years; at the end of one tariff period, the BGS proposed a new tariff. While the BGS was responsible for proposing a tariff, the RVA had to approve each tariff before it could go into effect, and the RVA could make suggestions to prod the BGS in a different direction.

The BGS recognized that some firms had many different plants with operations that differed in their risk to works. They thus assigned each establishment (*Betrieb)* to a "risk class" (*Gefahrenklasse*) that reflected in principle the expected costs of accidents in an establishment of that type. A risk class for a given BGS might consist of heterogeneous plants such as rolling-mills and smelters; the idea was to group plants together if their accident risks were similar, not to group establishments by technology or product. A large, multi-establishment firm might have plants spread out across many risk classes. The BGS then reckoned each member firm's contribution units (CU_i) as a weighted sum of the total wages and salaries (W_i) paid to workers in each risk class and the "risk level" or "risk figure" (G_i) associated with each class. A firm's size affected its contribution through W_i.[15]

This system incorporated an element of experience rating, but not in the way that term is usually understood. Experience rating in a modern insurance system means that a given firm's premium reflects both its inherent risk, due to its activity (for example, manufacturing engines), and an adjustment upwards or downwards that reflects that firm's own accident history. The adjustment gives firms a financial incentive to improve their safety record, and helps the insurance company cope with otherwise unobservable differences among its clients. Experience rating in the BGS system was cruder. First, the relevant experience was for *all establishments of a given type within a BGS*, not for a particular firm. Thus a firm with a plant in risk class A would see its insurance costs go up or down with accidents in risk

[15] A detailed description of the contribution calculation can be found in the Rheinisch-Westfälische Maschinenbau- und Kleineisen-Berufsgenossenschaft: Statistische Tabellen zur Ermittlung der Gefahrenziffern für den vom 1. Januar…, BArch R 89/15626.

class A, even if those accidents occurred in plants belonging to other firms in the BGS. This subtlety was poorly understood in the early years of the insurance system; BGS boards had to re-explain the system, over and over, to firms that had experienced few accidents but that nonetheless were assigned to high risk classes. For example, the board of the Rhein-Westphalian engineering and small iron industry felt it necessary to give the following explanation in 1893, some eight years after the system was created:

> It has also been mentioned here that the risk figures are calculated for the entire group of similar firms and that within this, every single member has to pay the contribution corresponding to its wage bill, regardless of whether accidents have occurred in a particular firm, because the possibility of an accident exists in all firms.[16]

Each BGS used its own accident statistics to construct these tariffs. In the method originally used, the average risk level of like firms in a sector was reported as a weighted sum of the number of accidents per 1,000 workers. For fatal accidents the weight was assumed to be 10; for accidents that caused permanent total incapacity, 30; for accidents that caused permanent partial incapacity, 15; and accidents that caused temporary incapacity were assigned a weight of unity (Hartmann (1900, p.9)). The weights were supposed to reflect the costs to the BGSs of different types of accidents. Widow's benefits were, for example, much less costly than the disability pension required for a permanently incapacitated worker.[17]

In May 1896 the RVA informed the BGSs that henceforth they must use a new way of calculating the figures. To capture the financial burden to the BGSs more accurately, the crude weights noted above were replaced by the expenditure of firms in each risk risk level on medical treatments and accident benefits for each type of accident, divided by the aggregate wages and salaries of the companies concerned. The RVA required this calculation to be based on *all data since the BGS was established*, and not just on accidents

[16] Rheinisch-Westfälische Maschinenbau- und Kleineisen-Berufsgenossenschaft: Statistische Tabellen zur Ermittlung der Gefahrenziffern für den vom 1. Januar 1893 ab neu einzuführenden Gefahrentarif, BArch R 89/15626.

[17] We can illustrate the original system using data provided by Hartmann (1900, p.11). Between October 1885 and December 1893, the textile BGS's wool-spinning mills experienced 72 fatal accidents, 12 accidents that resulted in permanent total incapacity, 652 accidents that resulted in permanent partial disability, and 109 accidents that resulted in temporary disability. The weighted average was thus (72 * 10) + (12 * 30) + (652 * 15) + (109 * 1) = 10,969. Since there were 209,257 full time employees in the period under consideration, the weighted accident rate per 1,000 workers was 52. The risk levels in each industry branch of a BGS were calculated in this way and then normalized to a predetermined range and collectively formed the operative risk level tariff for a period lasting up to 5 years. Table 2 reports the scheme for the smelting and rolling mill BGS of Rhineland-Westphalia.

recorded under the most recent agreement.[18] The company-specific contribution units (CU_i) of the member firms (1...n), which were calculated as a product of total wages and salaries (W_i) and the risk level (G_i), became the basis for allocating the BGSs' financial burden. In the second step of the assessment system the individual contribution for a firm i (C_i) was determined as the product of its relative share in all contribution units (c_i) and the total expenditures of that year (E):

$$C_i = c_i \cdot E = \frac{CU_i}{\sum_{i=1}^{n} CU_i} \cdot E = \frac{W_i \cdot G_i}{\sum_{i=1}^{n} W_i \cdot G_i} \cdot E \qquad (1)$$

Suppose the sum of the individual contribution units (CU_i) was 1000. A member firm with 100 units therefore had a relative share (c_i) of 10% of all the contribution units. If the BGS's expenses (E) came to a total of 50,000 marks, this firm would pay 5000 marks (C_i) to the BGS, irrespective of the costs that the firm itself had caused. For most of the period under study here, the average BGS collected from firms a sum representing about 1.6 percent of the wage bill.[19] But there is a great deal of dispersion around that mean; the top twenty five percent of BGS collected about 2 percent, while the bottom twenty five percent collected about .1 percent. Variations in costs across industries line up very closely with the variations in accident rates reported in Table 1.

3. A model of incentives with the BGS cost allocation

Before considering the historical episode in detail, we first outline a simple model to evaluate the incentive effects implicit in the Reich Liability Act of 1871 and the later BGS' tariff system. Assume that firm (i) produces output (y) with the two inputs, labor (l) and capital (c). The firm's technology can be described by the following production function:

[18] Schreiben an die Vorstände der gewerblichen Berufsgenossenschaften vom 18. Mai 1896, BArch 89/630.
[19] Hartmann (1900, p.5) reports that in 1898 the Hannover's demolition/construction BGS carried the heaviest load in this year, paying premium amounting to about 10 percent of its wage bill. This figure is much higher than what appears in our data.

$$y = f(l,c) \tag{2}$$

Assuming a competitive environment with given output price (p), wage (w) and interest rate (r), profit maximization leads to the well-known maximum-profit condition

$$\frac{\partial y / \partial l}{\partial y / \partial c} = \frac{w}{r} \tag{3}$$

The firm's production plan (y^0, l^0, c^0) is optimal if and only if the ratio of the marginal products of labor and capital is equal to their price ratio. We use this production plan in the following as a benchmark. Suppose now that a strict liability law is introduced which requires the firm to bear the (expected) economic costs of accidents per worker (g_i). We can interpret these costs as the firm's individual risk level determined by its particular production technology. The firm can reduce the (expected) economic costs of accidents per worker to (g_i-e_i) by implementing additional safety practices or by introducing less risky production methods. However, the accident-reducing effort (e_i) also involves convex costs $v(e_i)$ with $v'(e_i)>0$ and $v''(e_i)>0$. The firm's profit function is now

$$\pi = p \cdot y(l,c) - (w + (g_i - e_i)) . l - r . c - v(e_i) . l \tag{4}$$

Profit maximization implies:

$$\frac{\partial \pi}{\partial l} = \frac{\partial y}{\partial l} - (w + (g_i - e_i)) - v(e_i) = 0 \tag{5}$$

$$\frac{\partial \pi}{\partial c} = \frac{\partial y}{\partial c} - r = 0 \tag{6}$$

$$\frac{\partial \pi}{\partial e} = l - v'(e_i) . l = 0 \tag{7}$$

Combining (5) and (6) we obtain the new maximum-profit condition:

$$\frac{\partial y / \partial l}{\partial y / \partial c} = \frac{w + (g_i - e_i) + v(e_i)}{r} \tag{8}$$

From (7) we know:

$$v'(e_i)=1 \tag{9}$$

From both the decreasing marginal productivity of labor and the fact that $g_i \geq e_i$, we see that the firm facing strict liability uses more capital ($c^L>c^0$) and less labor ($l^L<l^0$) to produce the same output. Liability has the same effect as a tax on labor and leads to an acceleration of mechanization. In addition, the firm now implements safety practices in the amount of e^L_i.

Now assume the liability law is replaced by an accident insurance system financed by a pay-as-you-go mechanism. The individual firm's contribution are not determined by its individual risk level (g_i) but by the average risk level (ag) of all member firms (1...n) (or a subset of firms with similar individual risk levels). This average risk level is calculated as

$$ag=\frac{1}{n}\sum_{i=1}^{n}(g_i-e_i) \tag{10}$$

Hence, the firm's individual profits are now

$$\pi=p.y(l,c)-(w+ag).l-r.c-v(e_i).l \tag{11}$$

Profit maximization implies:

$$\frac{\partial\pi}{\partial l}=\frac{\partial y}{\partial l}-(w+ag)-v(e_i)=0 \tag{12}$$

$$\frac{\partial\pi}{\partial c}=\frac{\partial y}{\partial c}-r=0 \tag{13}$$

$$\frac{\partial\pi}{\partial e}=\frac{1}{n}.l-v'(e_i).l=0 \tag{14}$$

From (14) we have

$$v'(e_i)=\frac{1}{n} \tag{15}$$

Comparing equations (9) and (15), we see that the insurance system leads the firm to care less about the implementation of safety practices than in the situation with strict liability ($e^{AG}<e^L$). The magnitude of the

reduction in e depends on the number of firms (n) used to calculate the average risk level. The impact on labor demand is ambiguous. Firms with a comparatively high individual accident risk (g_i) (for which $g_i - e_i^L + v(e_i^L) > ag + v(e_i^{AG})$), will increase their labor demand with the transition from strict liability to the accident insurance scheme. The opposite is true for firms with a comparatively low individual risk level. Thus the introduction of the accident insurance has the perverse effect of channeling workers into those firms where they face an above-average risk of an accident.

Suppose instead that the BG assigns a fixed, individual risk level (fg) to every member firm. We assume this risk level cannot, at least in the short run, be influenced at all by a firm's own efforts to increase workers' safety. Then, the firm's profit is:

$$\pi = p.y(l,c) - (w + fg).l - r.c - v(e_i).l \qquad (16)$$

The first-order conditions are:

$$\frac{\partial \pi}{\partial l} = \frac{\partial y}{\partial l} - (w + fg) - v(e_i) = 0 \qquad (17)$$

$$\frac{\partial \pi}{\partial c} = \frac{\partial y}{\partial c} - r = 0 \qquad (18)$$

$$\frac{\partial \pi}{\partial e} = -v'(e_i).l = 0 \qquad (19)$$

From (19) follows

$$e_i = 0 \qquad (20)$$

In the case of fixed risk levels, firms have no incentive to reduce the (expected) economic costs of accidents per worker. Summing up, our analysis implies $e^L > e^{AG} > e^{FG} = e^0 = 0$. Both in a system without compensation of workers' accidents costs and under an accident insurance system with fixed risk levels, firms will not be motivated to increase worker safety. The consequences are worse, however, in the insurance system because of the induced re-allocation of more workers to relatively dangerous sectors.

Pre-1871, Germany had no reliable system for forcing firms to pay for the economic consequences of industrial accidents. The 1871 Liability Act changed that ($e^0 \rightarrow e^L$), and then the 1884 Accident Insurance Act created the system under discussion in this paper. The fixed risk levels and lack of firm-level experience-rating in the original post-1884 scheme reduced firms' incentives to reduce accidents in their operations ($e^L \rightarrow e^{FG}$). Under pressure from the RVA, at the end of the nineteenth century the BGS began to use more and more risk classes, in effect assigning firms to pay rates that more nearly reflected the costs they incurred for the BGS. The differentiation of tariffs into many different average risk levels increased member firms' incentives to increase workers' safety ($e^{FG} \rightarrow e^{AG}$).

4. Accident insurance and its discontents

Our model implies three different incentive effects from the way the BGS allocated costs. All were known to contemporaries. First, the system encouraged the substitution of capital for labor. A firm could not change its assignment to a given risk class, and any firm's conduct had only the smallest (and delayed) effect on the contributions due from a firm in that class. But a firm could reduce its insurance costs immediately by reducing the wage bill. Thus a system intended to protect workers from the costs of industrial accidents might leave them unemployed.

Second, the system did not necessarily reward investments in equipment or research that would reduce the risk of accidents, even if somehow all the firms in a given risk class collaborated to make these investments simultaneously. This effect has two components. Any reduction in costs would affect the firm's situation only after the adoption of a new risk tariff, which might be three or four years in the future. Moreover, because the RVA insisted on basing current risk calculations on the *entire history* of the BGS, the effect of changes today was muted by practice in the past. This approach annoyed some BGS, who noted, correctly, that it meant they could be paying today for practices they no longer used. For example, the serious but not fatal accident rate for the iron and steel BGS prior to 1909 was 5.8 accidents per thousand worker-years. In 1910, it was 4.7. Any iron and steel BGS that revised its tariff after 1909, however, was required to use information on accidents produced by the production conditions that had created the much higher, earlier rate. As the smelting and rolling mill BGS complained in 1915:[20]

> the basis for the risk level is no longer applicable. [...] It does not take into account the fact that the new modes of operation, the introduction of electricity and of various new machines as well as the success of accident prevention would have resulted in a very different burden allocation than the one of the past decade and a half. New and better equipment would undoubtedly have reduced the operating risks. Therefore we might consider whether the old century should not be taken into account at all so as to better capture the new situation."[21]

As the engineering and small iron industry BGS remarked in the same context, "every risk level […] is made not for the past, but for the future."[22] This BGS resisted the RVA more than others. In 1896 it proposed a revised tariff that was based on only three years' worth of accident data, in open defiance of the RVA's regulations. When questioned, the BGS replied that its new safety rules had made earlier data a poor predictor of future accidents. In 1913 the BGS proposed a revised tariff that used data back to 1890 (but not to the system's beginning), but also included alternative calculations showing how misleading the RVA's approach was.[23]

The RVS's insistence on using all available historical data is hard to understand. The RVA explained it by an appeal to the law of large numbers: only by using all available information could the BGS calculate the right risk levels.[24] This argument reflects faulty statistical reasoning. If the underlying parameters of the process generating accidents changes, then there is little to learn from using old data. Perhaps more importantly, the RVA often appealed to what it thought were insurance principles; the most

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[20] Formerly the Rheinisch-Westfälische Hütten- und Walzwerks-Berufsgenossenschaft.

[21] Hütten- und Walzwerks-Berufsgenossenschaft, Aufstellung eines neuen Gefahrentarifs vom 1. Januar 1915, Rundbrief des Vorstands vom 16. August 1915, BArch R 89/15623. ("..*dass die Grundlagen für den Gefahrentarif nicht mehr zutreffend seien.* [...] *Er berücksichtige* [...] *nicht, dass die neuen Betriebsweisen, die Einführung der Elektrizität und vieler neuer Maschinen sowie die Erfolge der Unfallverhütung das Belastungsverhältnis gegenüber den ersten anderthalb Jahrzehnten der gesetzlichen Unfallversicherung ganz anders gestaltet hätten. Neue und bessere Maschinen hätten die Betriebsgefahren zweifellos verringert. Deshalb wäre zu erwägen, ob das alte Jahrhundert nicht ganz auszuschalten sei, um die neuen Verhältnisse besser zu erfassen.*")

[22] Letter from the Maschinenbau- und Kleineisenindustrie-Berufsgenossenschaft to the Reich Insurance Office vom 11. Januar 1904, BArch 89/15627.

[23] The material is in BArch R89/15626 and R89/15628. The alternative calculations are unfortunately not with the letters to the RVA.

[24] Rundschreiben an die Vorstände der dem Reichsversicherungsamt unterstellten gewerblichen Berufsgenossenschaften betreffend Festsetzung der Gefahrenziffern und Abänderung der Ausführungsbestimmungen zu den Gefahrenziffern vom 25. November 1908, BArch R 89/1201.

important thing was for firms to share risks within a BGS. But the *way* firms share risk within a mutual organization like a BGS shapes the incentives to expend funds on the prevention of accidents.

Third, the most important incentive effect of the assessment system was the externality noted above: it was almost never cost-effective for any individual member firm to invest in accident-reducing measures. (Conversely, an increase in the number of accidents also caused no significant increase in individual contributions.) Equation (1) shows that the increase in a BGS's expenses (ΔE) that resulted from an increase in accidents of a single firm led to a relatively small increase $c_i \Delta E$ in the contribution of the actual causer, where c_i, is smaller, the more companies belong to a BGS. [25] Most of the rise in accident costs [that is, $(1-c_i)\Delta E$] was passed on as externality to other firms in the BGS.

Contemporaries questioned the RVA's approach, noting the perverse incentives. Germans had experience with more differentiated systems. Private-sector liability insurance issued in response to the 1871 Liability Act typically used a more complicated tariff structure, incorporating firm-level histories in setting insurance premia. As Poeverlein (1900, p.17) put it, "Under private insurance, determination of the contributions reflected the greatest possible individualization of risk, following technical insurance principles; with accident insurance, on the other hand, it more or less took place according to generalized assessment standards." At some level the practices adopted by the BGS reflect a step back.

The BGS were aware that firms with above average accident expenses increased all member firm contributions. The requirement to join a BGS made adverse selection at the system level impossible under the 1884 accident insurance legislation. But individual BGS sometimes tried to affect their own costs by attracting or repelling particular firms. An economy as developed as Germany's in the 1880s was bound to have firms that would not fit easily into a reasonable number of industrial categories, and some conflict reflected which BGS had to take the firms that did not naturally fit anywhere. BGS sometimes tried to prevent a particularly high-risk firm from joining. In 1889, for example, the south German precious and

[25] Note that a firm's relative contribution also depends on its (relative) size. One could imagine a firm that owned all plants in a given danger class; in this case there would be no externality. Because of the role of historical data in the construction of risk estimates, however, such a firm would continue to pay premia that did not reflect the full reduction in risk associated with the safety improvement. In any case, we are unaware of any firm that employed all the workers in a risk class.

base metal BGS tried to exclude Lorenz, a firm that made metal cartridges and machines. Lorenz's works included the hazardous activity of filling cartridges with gunpowder. The south German precious and base metal BGS's board thought this activity a more natural fit to the chemical industry's BGS.[26] That fact that a BGS would want to rid itself of a member firm suggests once again that the premium system was imperfect; in principle, a BGS should not care about its membership, so long as it could price all risks correctly.

Even if a BGS could not exclude a comparatively risky firm, the BGS could abuse the firm in ways that made its situation unattractive. A small firm that played only a marginal role in its BGS was at risk of being assigned unjustified, high risk levels. One example of this problem comes from the southwest German iron BGS. Among the "misfits" belonging to this BGS were firms that operated steam rollers. In 1889 this BGS's risk levels ranged from 5 to 50, and it assigned the steam rollers to the class with a risk level of 35. In 1906 the BGS revised its tariff so that the overall levels ranged from 5 to 70, and assigned the steam rollers a level of 50.[27] At the 1909 BGS meeting, the steam road roller operators objected to the proposed new figure of 23, calling instead for a classification with the much lower risk figure of 8.5. The other member firms overwhelmingly rejected this proposal.[28] The steam roller operators then appealed to the RVA. The regulator's intervention eventually succeeded in persuading the southwest German iron BGS to lower the rollers' risk figure to 16. This number more nearly reflected the estimate one would draw from the steam rollers' own accident statistics, 15.04.[29] In this case the BGS had tried to ignore its own statistical information and assign the steam roller firms a risk figure fifty percent higher than was warranted. This example also shows the RVA's power: when it cared to, the regulator could shape the negotiation of the new tariffs.

[26] Jahresbericht der Handwerkskammer für den Amtsbezirk Pforzheim, 1989, BArch 89/1095.
[27] Gefahrentarife der Südwestdeutschen Eisen-Berufsgenossenschaft 1899 und 1904, BArch R 89/15619, R 89/15620.
[28] Extract from the Protokoll der ordentlichen Genossenschaftsversammlung der Südwestdeutschen Eisen-Berufsgenossenschaft vom 30. September 1909, BArch R 89/15620.
[29] Brief von der Südwestdeutschen Eisen-Berufsgenossenschaft an das Reichs-Versicherungsamt vom 14. Dezember 1909, BArch R 89/15620.

All of these problems were made worse by the BGS practice of creating tariff structures consisting of a few risk classes with similar risk values. In the 1880s, the mean number of risk classes for all BGS was 6.6, and the mean absolute span (ratio of the highest to the lowest risk level) was 9.8. This practice made little sense, given the range of firms grouped within a single BGS. For example, in the late 1880s, the Rhein Westphalian smelting and rolling mill BGS assigned 87 percent of its member firms (weighted by the number of workers) to the risk levels 35, 50 or 65.[30] This limited range probably reflects the fact that in the 1880s the BGSs did not yet have the long-term accident statistics required to assign individual establishments to specific risk levels:

> At the founding of a *Berufsgenossenschaft* for accident insurance the main concern of the individual firms was that they would be cheated during the assessment of the risk categories because each manufacturer believed his firm to be the least dangerous. This general fear is also the reason for the effort by many industrialists to group only firms of the same type in a BGS.[31]

But lack of information was not the only problem. BGS boards found it difficult to assign realistic risks to sectors that were financially dominant within the group. Until 1918, for example, the Rhein-Westphalian engineering and small iron industry BGS clumped together three different types of machine-building firms. When the BGS finally split them up, they were in three different classes with very different risk levels, showing that the earlier assignments had been way too crude.[32] In another example, the Rhein-Westphalian smelting and rolling mill BGS assigned two groups of firms, non-iron smelters and gun-drillers, to the same risk level of 35 in 1897. But the BGS's own data showed how different the two groups were. The non-iron smelters had a statistical risk figure of 25, and the gun drillers a figure of 56.[33] The gun drillers cost the BGS more than twice as much as the smelters, but, for a given firm size, paid just as much in insurance contributions.

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[30] Unfallverzeichnis der Rheinisch-Westfälischen Hütten- und Walzwerks-Berufsgenossenschaft vom 1.Oktober 1885 bis 31. Dezember 1891, BArch R 89/15622. See also table 2.

[31] Vorschlag zur Ermittlung der Gefahrenklassen für keramische Gewerbebetriebe, Max Rösler, 15. Februar 1885, BArch R 89/15900.

[32] Rheinisch-westfälische Maschinenbau- und Kleineisen-Berufsgenossenschaft: Erläuterungsbericht zum Unfallverzeichnis für den Gefahrentarif 1918 bis 1922, BArch R 89/15628.

[33] Unfallverzeichnis der Rheinisch-Westfälischen Hütten- und Walzwerks-Berufsgenossenschaft für die Periode vom 1. Oktober 1885 bis zum 31. Dezember 1897, BArch R 89/15622.

§28 of the accident insurance law did allow a BGS to impose on an individual firm a higher or lower tariff than would be implied by the general tariff scheme. With the help of these surcharges or discounts the BGS could move in the direction of firm-level experience rating, and thus condition the relative contribution units (c_i) on *firm*-level experience. Some BGSs formally adopted such provisions in their tariffs, but the practice was rare. Reluctance to use this approach reflected the perception that it would cause trouble with the affected firms, but not produce much in the way of change. For example, the board of the BGS for precision mechanics and electrical engineering claimed in 1909 that „an increase or discount of the standard risk levels [...] has not been executed in any case, since we lack sufficient reason for it.“[34] Other BGS explicitly opposed the introduction or retention of such regulations. The board of the northwest iron and steel BGS explained in 1914:

> The board does not want the power to decrease the risk level in a case of lower risk, because there would be a host of applications for discounts, and if granted these discounts would only create dissatisfaction. The board also does not attach great value to the possibility of increased risk levels and thus has rarely made use of its authority.*“*[35]

This was not the only BGS board that lacked the will and the resilience to use premia to reward good behavior and punish dangerous practices.

Faced with this passivity, the RVA increasingly pressed for more differentiated tariffs. One well documented case illustrates this lengthy negotiation process in detail. Until 1900, the Rhein-Westphalian smelting and rolling mill BGS's tariff had only six risk classes. That figure was increased to seven in 1900. Only in 1910 did the BGS shift to a structure with 33 risk classes, despite its growing database of accidents and the ability to construct a more differentiated tariff based on its own history. The RVA had long objected to the BGS's approach: for the tariff starting in 1900, the RVA wanted 26 (!) different classes. The BGS professed to understand the advantages of a greater number of groups, but still refused

[34] Brief des Genossenschaftsvorstands der Berufsgenossenschaft der Feinmechanik und Elektrotechnik an das Reichversicherungsamt vom 6. März 1909, BArch 89/15613.

[35] Letter from the Genossenschaft board of the Nordwestlichen Eisen- und Stahl-Berufsgenossenschaft to the Reich Insurance Office from March 24 1914, BArch R 89/15642. A similar argument had been made in 1899 by the board of the Rhein-Westphalian engineering and small iron industry BGS. Compare Brief des Vorstands der Rheinisch-Westfälischen Maschinenbau- und Kleineisenindustrie-Berufsgenossenschaft an das Reichs-Versicherungsamt vom 13. Juli 1899, BArch R 89/15627.

to implement this suggestion. The explanation was self-contradictory: "While being completely aware of the fact that a greater number of risk levels would cause a more correct use of the figures based on the accident register for every firm, we still believed that the resulting small deviations from the accident register would not be in the interest of the overall structure of the tariff."[36] The RVA was willing to compromise and instead suggested that the number of the groups be increased from 6 to 13. The BGS nevertheless rejected also this suggestion:

> The purely mechanical procedure based on the statistics that has been favored by the Reich insurance office excludes every opinion, grounded in practical experience, of the members of the association; and the current action of the office [the RVA] can be characterized as interference in the right of self-determination of the association [BGS], which cannot be legally justified. The Reich insurance office has no cause to complain when the association sets a risk rate through its own institutions, of which it cannot be claimed that there was a procedure in violation of correct principles.[37]

Figure 1 shows that the RVA's ongoing insistence eventually achieved success. BGS in some of the more dangerous industries were enthusiastic converts to the cause of more danger classes; between 1909 and 1915, the groups rose significantly in all iron and steel BGS, reaching 69 classes in the southern German iron and steel BGS. Even the Rhein Westphalian smelting and rolling mill BGS finally came around and, in 1910, increased the number of groups from 7 to 33. In their defense of the proposed rates they adopted the RVA's arguments:

> With this [traditional] way of allocation to the risk groups, the difficulties and benefits of the contribution increase could not be avoided. An enterprise, such as the coal gas stations, that had the liability figure 17.7 (1885/1903) joined the group A and had to adopt a figure of 25 in the contribution calculations. Another enterprise, for example the iron foundries with the liability figure 41, were assigned to group B and paid only 35. At the encouragement of the Reich insurance office and in agreement with it, the current revision should change this procedure, and the liability figures of the individual industry branches implied by the accident record should immediately substitute as the basis for the risk figure. It is clear that in this way, a more correct and fair inducement to pay contributions is created.*"*[38]

[36] Letter of the board of the Rheinisch-Westfälischen Hütten- und Walzwerks-Berufsgenossenschaft to the Reich Insurance Office, August 14 1899, BArch R 89/15622.
[37] Protokoll der 16. Genossenschaftsversammlung der Rheinisch-Westfälischen Hütten- und Walzwerks-Berufsgenossenschaft, August 26 1899, Bericht des Vorsitzenden, BArch 89/15622.
[38] Protokoll der Genossenschaftsversammlung der Rheinisch-Westfälischen Hütten- und Walzwerks-Berufsgenossenschaft, 6. Juli 1910, Punkt 5 der Tagesordnung: Revision des Gefahrentarifs, BArch 89/15623.

The RVA's successful pressure to create more groups had two effects. First, by creating more groups a BGS ensured more homogeneity within a group. Second, by reducing the number of firms assigned to a group, the BGS gave each firm a greater impact on its own future contributions. Both effects linked a firm's financial contribution more tightly to its own record. The RVA hoped this new incentive structure would motivate firms to adopt better worker protection.[39]

Using Rules

The insurance rates offered the BGS an imperfect instrument for encouraging firms to reduce accidents, and most were reluctant to use its full power. The BGS had another tool at its disposal: it could directly impose better practices on member firms. This approach had two parts. The BGS could issue rules (*Unfallverhütungsvorschriften*) designed to force firms to adopt safety devices or production methods that reduced certain well-known risks. One important set of rules, for example, required covers on power-transmission belts and similar moving parts. The second aspect of the rules approach was inspectors who had the power to verify that the rules were being followed, and to recommend fines against firms that did not adhere to the rules.[40]

Industrial practice at the time offered opportunities for small changes that would make the workplace safer. This was a constant theme in the RVA's newsletters. In a letter of June 1890, for example, the RVA claimed

> It can be recognized from the accident statistics that almost a quarter of all serious accidents that are caused by machinery occur in connection with transmission belts and gears. In 269 cases, workers got caught in the belt and were injured. In 731 cases, workers ended up in the wheels gear, most of which lacked a cover. These figures suggest that it is in the interests of effective accident prevention to install belt boxes, wheels tops and belt and wheel railings, and

[39] The hope for a similar incentive effect was expressed in September 1869 at the meeting of the *Kongress deutscher Volkswirte*. Speaker Karl Braun stated: "The best regulator is always
the own interest of the mining companies. It occurs in a similar manner in other areas, for example with the railway administration. […] In short, we want to make the law so forceful that it prevents accidents." Verhandlungen des Kongresses deutscher Volkswirte über die Reformbedürftigkeit des Haftungsrechts, September 1869, printed in: Born et al (1993), 33 f.

[40] In 1913, the average BGS levied almost six thousand Marks in fines, and one-quarter of all BGS received more than 8300 Marks in fines. Six thousand Marks was equivalent to 51 Marks per million Marks paid in wages in that year, so for the average firm the fines were a small expense. The sources available to us do not report the distribution of fines among firms.

> simultaneously to adopt a rule whereby the production belts may be replaced only at slow speed or when the machine has been switched off. [41]

Firms often resisted the introduction of these rules. Given the externalities implicit in the system of risk calculation, it is no surprise that individual firms ignored recommendations on safety practice. One can view the inspectors and fines as an effort to align the firm's interest with those of the BGS. Figure 2 shows that over time, the BGS spent more and more money on writing and trying to enforce the safety rules. (The sharp jump at the outset apparently reflects the large costs of writing the first set of initial rules). From 1900 to 1914, these expenditures nearly doubled as a fraction of all insurance contributions. Inspectors' salaries comprise the majority of such costs. The BGS were getting more serious about requiring their members to use the safety techniques the body demanded. The slight decline in income from fines over our period may reflect that vigilance; firms were more sure of getting caught, and so were more consistent in avoiding conduct that could get them fined.

5. The outcomes: accidents

So what was the net effect of the imperfect incentives implied by the risk tariffs, and the BGS's ability to write and enforce safety rules? The RVA's data include a careful reckoning of accidents, dividing them into several categories that reflect the accident's financial consequences. We re-work the RVA categories slightly to compute the risk of an accident (per thousand worker-years) of any type; of fatal accidents; of accidents that were serious but not lethal; and of other accidents, which we will call "minor."[42] The classifications reflect the consequences for the worker, and correspond imperfectly to the financial implications for the firm. The death of a worker with no survivors could cost less than long-term support for a permanently disabled worker. Figure 3 reports the accident experience of all BGS in our period, and demonstrates both the successes and failures of the system. Overall accident rates rose

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[41] Rundschreiben an die Vorstände sämtlicher ausschließlich vom Reichs-Versicherungsamt ressortierenden Berufsgenossenschaften, betreffend die Unfälle, die infolge von Blutvergiftung den Tod der Verletzten herbeigeführt haben, sowie die Unfälle an Treibriemen und Zahnrädern vom 17. Juni 1890, BArch 89/628.

[42] These are the categories used in modern ILO reports. Serious, non-lethal in our usage is the RVA's category of accidents that cause continuing inability to work (*dauernd Arbeitsunfähigkeit*).

steadily, and only declined after 1907. But this view masks important changes in the incidence of different types of accidents. Lethal accidents declined slowly, but they did decline (regressing lethal death rates on a linear time trend yields a slope coefficient of -.0036 with a t-statistic of -4.57). Serious, non-fatal accidents declined by about one-half from the mid-1890s to 1914. The overall accident rate looks worse than it would otherwise because of the steady increase in minor accidents.

We are interested in how these changing accident rates reflect BGS-level decisions about insurance rates, rules, and other matters. But there are two very different issues that must be addressed first. First, the increase in minor accident rates combined with decreasing serious accident rates raises questions about reporting and, more interestingly, the possibility that improved safety practices sometimes reduced the *severity* of an accident's outcome, rather than reducing the *incidence* of accidents. The reporting issue is one that affects many studies of accident-insurance systems. If employers have an incentive to call a serious accident minor, then we must be careful about the margin between those two outcomes. (The reverse might also be a problem.) In our view, the fatal and serious accident categories are fairly trustworthy. Accidents leading to deaths are very hard to conceal. And both practice and incentives suggest more serious, non-fatal accidents were reported. All accidents had to be reported to the local police, and workers always had the right to challenge the determination of the accident's severity. Any effort to shift a serious accident to the minor category could trigger a worker grievance, a grievance that would have to be reported to the RVA and that would ultimately be settled by an arbitration panel.

On the other hand, the margin between a minor accident and no reported accident at all could reflect a host of consideration that make the "minor accident" category unreliable (at least over time and across firms). Consider a case where a heavy object hits a worker, resulting in a bruise. One could imagine the incident being considered an accident, with reports, compensation etc. On the other hand, the affected worker might just shrug it off, or be given some informal compensation (such as the rest of the day off) that would not show up in our accident statistics. In what follows we consider accidents under all three headings, but we are more than a little skeptical of the reports on minor accidents.[43] Because the "all accidents" category includes minor accidents, we must be skeptical of it, too.

We also consider the possibility that improvements in safety practices could shift the actual impact of an accident from the "fatal" to the "serious" category or from the "serious" to the "minor" category. The effect in either example is that a new practice that made accidents more survivable, or that made formerly serious accidents minor, would look like an increase in the less-grave type of accident, when in fact it reflects an improvement in safety. This situation would arise if a change in equipment or practice made some accidents more survivable, or if an accident that would formerly incapacitate a worker become one from which he could recover and return to work quickly. These possibilities imply that the increase in minor accidents documented above could be a sign of the system's *success* rather than its failure. To address this possibility, we estimated (but do not report) a series of models in which the dependent variable is one accident rate (for example, fatal accidents) and the regressors include lags of another accident rate plus year and BGS fixed effects. This approach does not suggest that fatal accidents were shifted to some other category. But the relationship between serious and minor accidents is very strong; a 10 percent decrease in serious accidents implies a 4.5 percent increase in minor accidents.[44] This result suggests care in examining any given type of accident rate as an outcome measure.[45]

One could also worry that a purely compositional effect might lurk behind the data presented in Figure 3. A change in Empire-level accident rates could reflect either a change in accident rates at the

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[43] Fishback (1987) raises a different issue, which is whether worker-years are the proper control for exposure to the risk of an accident. If working time is pro-cyclical then workers will face more exposure to accident risk during economic booms. Our regression estimates below use year fixed-effects in part to control for this issue. But we agree that it would be better to have industry-level measurs of working hours, which are not available.

[44] The statement in the text refers to the elasticity at the means. The estimate is -.560 with a t-statistic of -13.67. The precise estimate is sensitive to the inclusion of lagged terms, but the basic result is robust.

[45] Both the RVA and the BGS were proud of their medical care and rehabilitation measures. Over the long run of the system's creation, one can imagine that improvements in care made it possible for some injured workers to return to work more quickly (or at all). But this effect would not show up in the regressions discussed in the text because of the year fixed effects. Another possibility is moral hazard, a claim that is a staple of contemporary observations of German factories and workplaces elsewhere. The claim is that firms would pay to install a certain type of safety improvement, but workers would either disable the equipment (because doing so made their jobs easier) or not follow safety instructions. We know no serious way to evaluate the moral-hazard claims. But it is unclear why they really matter; surely firm accident-prevention efforts should be thought of as encompassing both equipment and practice, and if firms had the right incentives they would ensure proper use of safety equipment.

BGS level, or a change in the relative sizes of BGS. Figure 4 illustrates the issue by focusing on two large sets of BGS, eight in steel and eight in textiles. The steel industry was considerably more dangerous than textiles. Employment in the steel industry also grew more rapidly than in textiles in the decade prior to World War I. The overall accident statistics would look better if the steel industry had grown more slowly and the textile industry more rapidly. But is this phenomenon general enough to play an important role in the national accident statistics? We can address this question using a simple counter-factual exercise. We fix the relative sizes of the BGS at the levels for 1886, but use the historical accident rates for each BGS. We then compute a counter-factual overall accident rate such as reported in Figure 3. The counter-factual varies only slightly from the historical aggregate accident rate, suggesting that the evolution of national accident rates does not depend heavily on the shifts in employment shares.

6. Regulating for safety

The BGS' diverse experiences suggest a close look at the determinants of accidents within each BGS. We are interested primarily in the mechanisms the BGS could use to reduce accidents: the number of risk classes, the span of the risk levels assigned by the current tariff, and the amount the BGS spent to enforce its rules. The first two variables are the key features of each tariff. The last, enforcement, we view as a proxy for the effort to use safety rules to reduce accidents. Our basic tool is a series of econometric models in which the dependent variable is a measure of the accident rate. We start with models where observations are BGS-years. We always include year fixed-effects to control for shocks common to all BGS (such as unobserved innovations in RVA policy or new technologies). The year fixed-effects should also help to standardize the accident rates by controlling for unobserved changes in working time, so long as those changes are similar across BGS. All specifications include the controls insured (the number of insured workers per BGS, a measure of size) as well as mean wages (the average wage per insured worker, a measure of the expected cost of an accident).

The sum spent each year on factory safety inspectors ("enforcement") is available from the RVA reports and we have it for all BGS-years. Two other policy variables require laborious extraction from archival reports. One is the number of classes in the BGS tariff ("classes") and the other is the range of risk levels ("span").[46] To reduce costs we did not collect classes and span for all BGS. The last column of Table 1 reports the availability of these measures in our data. The overall sample has 1943 BGS-years of observation; when using these two archival variables, we have 1477 BGS-years of observation. The mean BGS for which we have these variables has about 103 thousand covered workers and an accident rate of 6.75 per thousand worker-years. BGS lacking these variables have an average of 105 thousand workers and an accident rate of about 6. Because our results on those measures rely on a sub-set of BGS, one could worry our results would be different for the entire universe of BGS. We cannot of course know what the effects in question would be for the other BGS, but the available information does not suggest systematic differences between the BGS for which we have these measures and for which we do not.

Two econometric issues require care. The three policy variables are certainly endogenous. The endogeneity could reflect simultaneity, unobserved heterogeneity, or both. In all specifications we use BGS-level fixed effects (FE) to deal with unobserved heterogeneity. While this is a standard approach in panel models, the heterogeneity across BGS might not be additive or fixed over time. For example, changing accident rates might reflect technologies that change differently across sectors over time (even among BGS in the same sector), or changes in the boards running the individual BGS. We also face the problem that because classes and span are fixed for a tariff period, these policy variables have no within-BGS variation for a given tariff period. In this case we shift to observations that are a BGS-tariff-period rather than a BGS-year.

Table 3 reports within-BGS fixed-effect (FE) estimates for all four types of accident rates. The models include but do not report year fixed effects. The two controls insured and mean wages have similar effects across accident types, and their effect is broadly invariant to the inclusion of the policy variables (the exception is minor accidents). Larger BGS had lower accident rates. This effect is very consistent. BGS whose workers are more highly-paid have higher accident rates. This result is consistent with the idea that labor markets price out risk in the form of higher wages in riskier settings, but we lack

[46] Both variables are defined in the appendix.

the wage data needed to test for compensating differentials precisely. We expect all three policy variables to have a negative relationship with accidents. The estimates reported in Table 3 confirm this expectation; the estimates for all three policy variables are either negative or statistically indistinguishable from zero. In columns (1), (4), (7), and (10) of Table 3, we enter all three policy variables at once, providing the implicit “horse race” that compares the effects of the several policy variables. In the other specifications we use either classes and span together, or enforcement alone. These estimates in Table 3 serve as comparisons for our IV results below. As a practical matter we cannot estimate models with three endogenous variables.[47]

The estimates in Table 3 might be inconsistent if the endogeneity in the policy variables reflects simultaneity. To deal with this issue we experimented with a number of possible instruments from the limited group of candidates available to us. We settled on two lagged exogenous variables. Each exploits the fact that when a BGS devised a new tariff, it had to use only information available at that time. Thus classes and range are fixed for the period of tariff t, but reflect information available at tariff period t-1. Last_mean_stock is the average number of past accidents for which the BGS was paying claims, and last_mean_ins is the average number of insured workers in that tariff period. Because of the fixed effects in the model, both instruments should pick up only aspects of the BGS's experience that might lead it to change policy direction in the new tariff period. The exclusion restriction is satisfied mechanically because the instruments are lagged and we have fixed effects.

Exploiting these instruments requires that we shift the unit of observation to coincide with the period for which a tariff was in force. Thus the estimates reported in Table 4 use as their observations the tariff-period means for each BGS. This reduces the number of observations considerably.[48] Table 4 reports

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[47] We experimented with combining classes and span into a single metric, for example, the average span per class. The results were broadly similar to what we report. The problem with this approach is that classes and span really capture two different aspects of the tariff. By adding more classes, the BGS was assigning risks more precisely. By increasing the span, it was making the more dangerous enterprises pay a higher premium A BGS could, and did, change one variable without affecting the other.

[48] Fixed-effect estimates analogous to those reported in Table 3, but based on the tariff-period observations, yields results similar to those reported in Table 3. This and the next paragraphs refer to models estimated but not reported here. All are available upon request from the first author.

GMM estimates of our instrumental-variables model.[49] None of the policy instruments affect all accidents; this might reflect reports of minor accidents, which we view as unreliable. For fatal and serious accidents, the number of risk classes and the amount of enforcement each have the expected sign and are statistically significant. For the two most consequential types of accidents (and the ones for which we most trust our data), the measures the RVA was pushing the BGS to take actually had an effect, even if the BGS resisted taking them.[50]

But how much did these policies matter? The elasticities implied by the estimates in Table 4 are large, given the slow and uneven pace of accident reduction documented at the outset. A 10-percent increase in the number of risk classes would lead to a 7.9 percent reduction in fatal and a 12.2 percent reduction in serious accidents. Increased enforcement had a smaller effect; a 10-percent increase in expenditure on enforcement reduced fatal accidents by 1.5 percent, and serious accidents by 1.8 percent. These elasticities are based on local effects, so we should not extrapolate them too far from the sample means. That said, the average number of classes increased nearly four-fold from 1885 to 1914; the average span, more than four-fold; and the average expenditure on enforcement even more. Above we stressed the design flaws that made it hard to a BGS to assign risk properly, and the reluctance of many BGS to use even the tools at their disposal. Our estimates imply that even these tools, however, were quite powerful, and that if the BGS had adopted them earlier and more universally, the hoped-for decline in industrial accident rates would have started earlier and progressed more rapidly.

[49] Table 4 combines all BGS and all years. We experimented with focus on a single industry (such as steel or textiles, for which they were multiple BGS). While constrained by the number of observations and our instruments, these results did not suggest radical differences in impacts across industry classes. We also split the sample at various points in the 1890s, when the RVA increased its pressure to use more classes and spans, and to increase enforcement efforts. Again, this exercise is limited by sample-size and instrument considerations, but suggested no structural break in the way the policy variables work.

[50] The instruments work well for the enforcement of rules, but for classes and span are probably "weak" in the sense of the recent literature on weak instruments. Consider the specification reported in column (3) of Table 4. The Angrist-Pischke test of excluded instruments is 7.77 (p=.0058). The Cragg-Donald Wald F is 5.09. The Stock-Yogo critical values in this case imply a maximal IV size of between 15 and 10 percent. Similar results obtain in other specifications using classes and span as endogenous regressors. For equation (4) of Table 4 (and specifications like it) the instruments have more power. The Angrist-Pischke test statistic is 16.36 (p=0) and the Cragg-Donald statistic is 52.79. The Stock-Yogo critical value for a maximal IV size of 10 percent is 19.93. Note that the results for classes and span reported in Table 4 are similar to those implied using the tariff-period data without instruments.

7. Conclusions

Germany's 1884 accident-insurance legislation is rightly famous as a central part of a larger system that eventually provided virtually the entire German population with economic security in the face of accidents, illness, or old age. The accident-insurance system in particular protected workers against the financial consequences of workplace mishaps. But the system enjoyed only disappointing success in reducing accidents, the number of which was an important motivation in the system's creation. This experience reflects in part legislation that made it difficult for the BGS to price firm-level risk appropriately, and the BGS's reluctance to use even the weak tools at its disposal. Nonetheless, our estimates imply that the tools available to the BGS had powerful effects, and, if used earlier and more generally, might have led to the desired outcomes earlier in the system's history.

The failure to reduce accident rates more rapidly than occurred may reflect another feature of the accident-insurance system, and a basic difference in the objectives of the BGS and their regulator. The accident-insurance legislation forced firms to pay (via the BGS) for the economic consequences of accidents, but ruled-out punitive damages. And the fines imposed for safety violations were for violation of a rule, but not to deter outrageous behavior. At some level, the 1884 law made industrial accidents too cheap for German industry, or at least too cheap to induce firms to improve safety to a level where accidents would be as rare as the RVA wanted. And this was the real reason for the RVA's stress on rules: it wanted safer factories than the allocation of costs visa the BGS would provide.

Appendix

The “BGS database” was constructed from the annual reports of the RVA, which in turn are based on the annual reports each BGS was required to file with the RVA. We cite these reports below as Reichs-Versicherungsamt (ed.), *Amtliche Nachrichten des Reichs-Versicherungsamts.* We augmented this information with several measures drawn from the archival files in the collection R 89 of the *Bundesarchiv* in Berlin. These are (1) *Number of risk classes* (1) the number of distinct classes in the periodic revisions of the insurance tariff. (2) *Span of risk levels*: this is the ratio of the highest to the lowest risk level in each tariff. Since most BGS set the lowest risk at unity, span is usually equivalent to the largest absolute difference. Information on the number of risk classes and spans of risk levels are taken from various files in which the RVA collected printed tariffs, letters, and other documents that dealt with the development of each BGS' particular tariff system. These files can be located with the help of Findbücher zu Beständen des Bundesarchivs Bd. 32: Reichsversicherungsamt Bestand R 89, Teil 2: Unfallversicherung, bearbeitet von Hans-Dieter Kreikamp, Koblenz 1987, Abschnitt 5.4: Gefahrentarife der Berufsgenossenschaften, p. 384 ff.

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Table 1: Overview of the BGS as of 1914

	Sizes of BGS				Accident rates		N Obs.	Classe/rules
	BGS	Establishments	Workers	Workers/Estab	All	Fatal		information
Construction	13	19541	1040862	5.3	18.1	1.5	387	yes
Apparel	1	12635	165379	13.1	3.4	0.1	30	yes
Mining	2	13343	1240588	93.0	10.2	1.4	60	yes
Inland water trans	4	20540	178217	8.7	12.2	2.7	114	yes
Printing	1	8700	51660	5.9	8.5	0.2	30	no
Chemical industry	1	15014	245980	16.4	7.2	0.7	30	yes
Iron and steel	8	48488	1315280	27.1	9.9	0.7	240	yes
Railways	2	746	211857	284.0	19.7	1.6	60	no
Energy industry	1	3756	72021	19.2	5.4	0.5	30	no
Precision engineering	1	8339	306773	36.8	5.8	0.5	30	yes
Drinks and tobacco	3	24788	157483	6.4	7.9	0.7	90	yes
Glass industry	1	1110	83069	74.8	3.5	0.2	30	yes
Trade	1	50667	40471	0.8	11.4	0.5	2	no
Wood processing	4	72462	393534	5.4	10.6	0.4	120	yes
Leather industry	1	8197	94087	11.5	4.9	0.3	30	yes
Metal production	2	6986	193915	27.8	7.1	0.1	60	yes
Musical instruments	1	1515	55196	36.4	3.4	0.1	30	no
Foodstuff	4	131717	654466	5.0	6.0	0.4	107	yes
Paper industry	2	5800	204699	35.3	6.4	0.3	60	yes
Smithing	1	57585	320586	5.6	2.5	0.1	13	no
Chimney Sweeper	1	4321	332185	76.9	0.1	0.0	30	no
Textiles	8	18717	911453	48.7	2.5	0.1	240	yes
Trans and storage	2	92591	431905	4.7	17.7	1.6	58	yes
Pottery	1	1456	77547	53.3	3.3	0.2	30	yes
Insurance	1	20819	47859	2.3	1.9	0.3	2	no
Brick manufacture	1	10228	181231	17.7	6.5	0.7	30	yes

Sources and notes for Table 1: *Source*: BGS database. *Notes*: Accident rates measures as accidents per thousand worker-years of exposure. N. Obs is the number of BGS/years of data in the panel. The final column reports whether we have information on the BGS tariffs; this information is used in section 7.

Table 2: Risk figures for the Rheinisch-Westfälische Hütten- und Walzwerks- Berufsgenossenschaft, October 1886

Risk class	Risk figure	Industry branches that belonging to this category
I	25	Lime works and supplementary brickworks
II	35	Silverworks, iron wire drawers
III	50	Blast furnaces
IV	65	Iron and steel rolling mills
V	80	Cast iron works, cannon foundries
VI	100	Iron bridge installations

Source: BArch R 89/15622.

Table 3:Fixed effects estimates with annual observations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Type of accidents (dependent variable)	All	All	All	Lethal	Lethal	Lethal	Serious	Serious	Serious	Minor	Minor	Minor
Insured	-0.00427	-0.00907	-0.00745	-0.00229	-0.00354	-0.00264	-0.00363	-0.00858	-0.0110	0.00165	0.00305	0.00620
	(0.0157)	(0.0164)	(0.00927)	(0.00106)	(0.00144)	(0.00109)	(0.00927)	(0.00975)	(0.00611)	(0.0142)	(0.0141)	(0.00465)
Mean wage	0.00520	0.00759	0.00796	0.00159	0.00221	0.00183	0.00473	0.00719	0.00811	-0.00112	-0.00181	-0.00199
	(0.00755)	(0.00789)	(0.00471)	(0.000532)	(0.000733)	(0.000528)	(0.00459)	(0.00486)	(0.00295)	(0.00709)	(0.00703)	(0.00251)
Classes	-0.0188	-0.0241		3.70e-05	-0.00136		-0.0101	-0.0156		-0.00872	-0.00716	
	(0.0194)	(0.0189)		(0.00150)	(0.00214)		(0.0150)	(0.0139)		(0.0188)	(0.0184)	
Span	-0.00734	-0.00835		-0.00137	-0.00164		0.00341	0.00237		-0.00937	-0.00908	
	(0.00959)	(0.0101)		(0.000989)	(0.00110)		(0.00534)	(0.00540)		(0.0102)	(0.00999)	
Enforcement	-0.0141		-0.0144	-0.00366		-0.00437	-0.0145		-0.00763	0.00410		-0.00238
	(0.00840)		(0.00397)	(0.00118)		(0.00103)	(0.00763)		(0.00318)	(0.00940)		(0.00416)
Constant	2.550	2.719	1.810	0.620	0.664	0.503	1.310	1.484	1.103	0.620	0.571	0.204
	(0.657)	(0.644)	(0.468)	(0.0812)	(0.0926)	(0.0564)	(0.406)	(0.396)	(0.283)	(0.482)	(0.454)	(0.266)
Obs	1,411	1,411	1,943	1,411	1,411	1,943	1,411	1,411	1,943	1,411	1,411	1,943
R-squared	0.551	0.547	0.602	0.112	0.083	0.195	0.367	0.353	0.442	0.537	0.537	0.556
Number of BGS	49	49	68	49	49	68	49	49	68	49	49	68

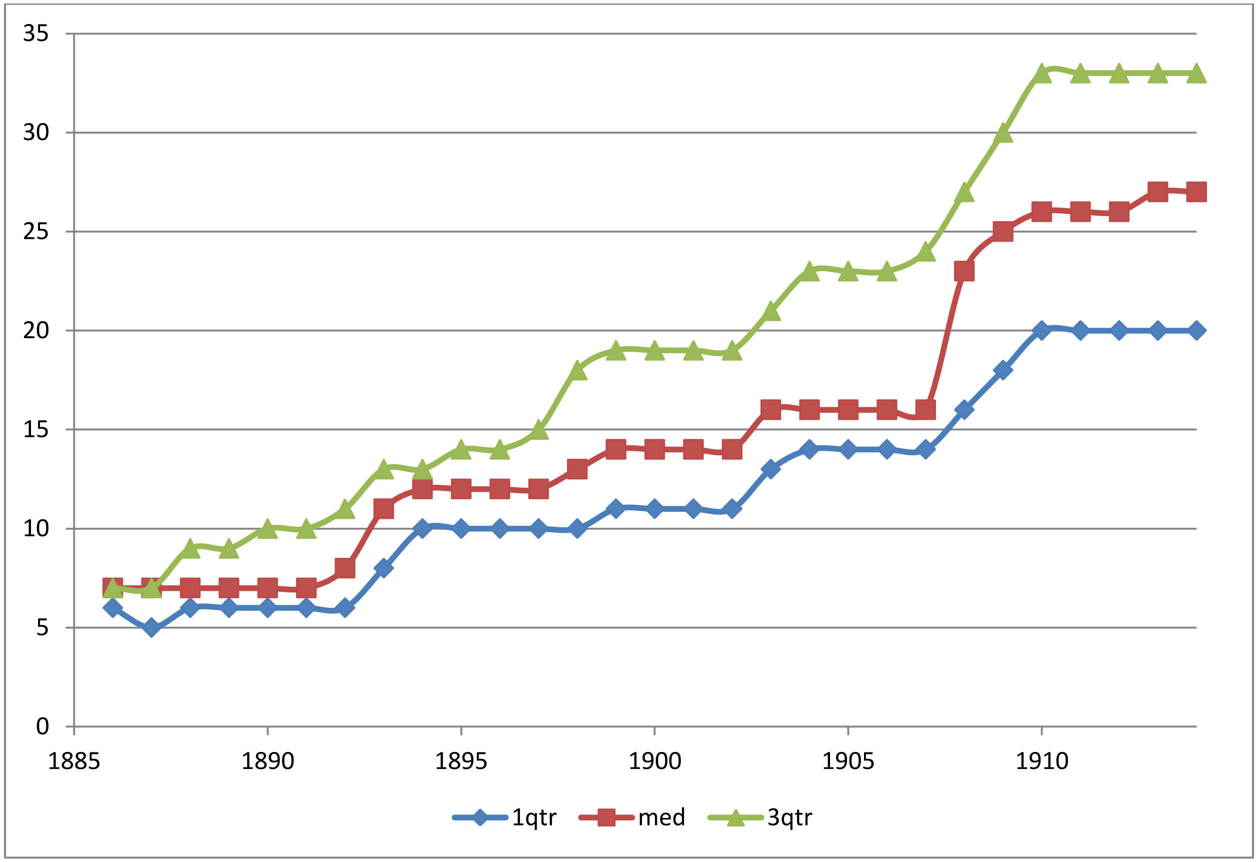
Note: Model includes unreported year fixed effects. The number of observations differs across specifications because Classes and Span are not available for all BGS.

Table 4: IV estimates of the effect of the policy variables

Type of accidents (dependent variable):	(1) All accidents	(2) All accidents	(3) Fatal accidents	(4) Fatal accidents	(5) Serious accidents	(6) Serious accidents	(7) Minor accidents	(8) Minor accidents
Classes	-0.0774		-0.0321		-0.243		0.198	
	(0.0890)		(0.0144)		(0.102)		(0.121)	
Span	0.0367		-0.000822		-0.0276		0.0651	
	(0.0397)		(0.00401)		(0.0384)		(0.0686)	
Enforcement		0.00269		-0.00623		-0.0384		0.0456
		(0.0204)		(0.00263)		(0.0113)		(0.0178)
Insured	-0.0271	-0.0254	-0.00508	0.00145	-0.0259	-0.00785	0.00388	-0.0168
	(0.0345)	(0.0149)	(0.00418)	(0.00306)	(0.0322)	(0.00687)	(0.0506)	(0.0118)
Mean wage	0.0158	0.0162	0.00332	-0.000238	0.0189	0.00746	-0.00640	0.00807
	(0.0169)	(0.00710)	(0.00199)	(0.00149)	(0.0160)	(0.00328)	(0.0256)	(0.00563)
Observations	271	326	271	326	271	326	271	326
Number of BGS	48	51	48	51	48	51	48	51

Note: Estimated by GMM. See text for definition of instruments and discussion of exclusion restriction and instrument strength. The observations in this table are the means of the relevant variables for a given tariff period for each BGS. The model includes unreported year fixed-effects. The number of observations differs across specification because the Classes and Span variables are not available for all BGS.

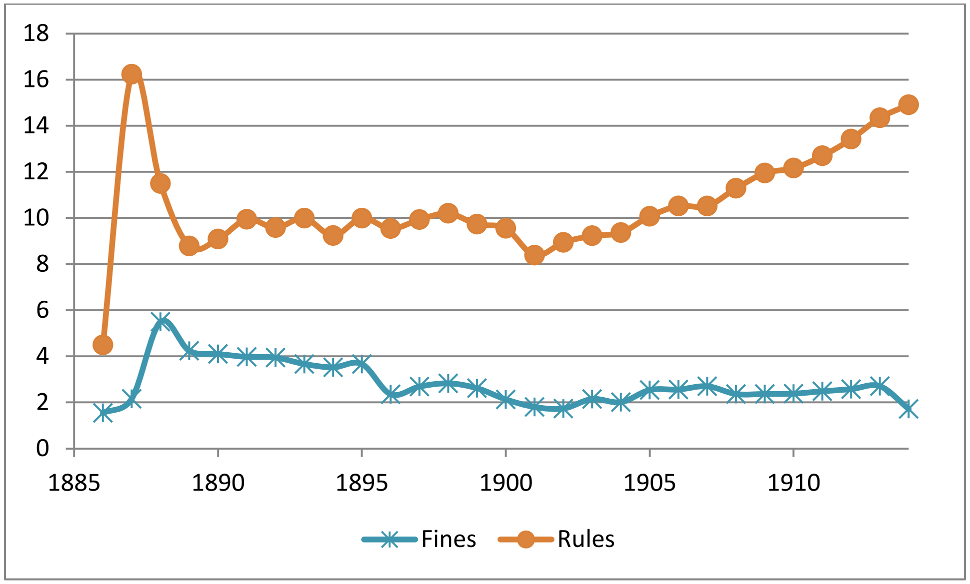
Figure 1: The number of risk classes per BGS, 1888-1914



Source: BGS database

Note: Figures are weight by number of insured in each BGS.

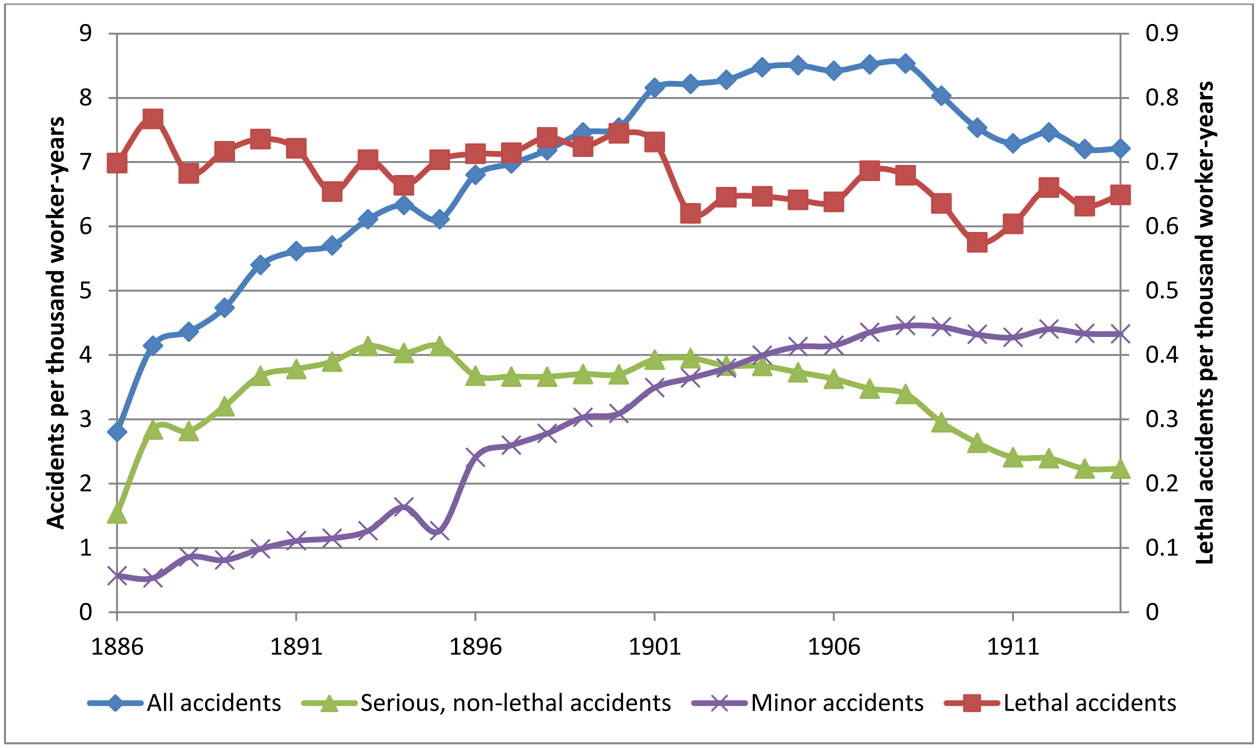
Figure 2: Expenditure on safety rules and income from violations of the rules



Source: BGS database

Note: "Fines" are total income from fines, per thousand Marks of contributions paid by member firms. "Rules" are total expenditure on safety inspectors, and inspection, normalized in the same way.

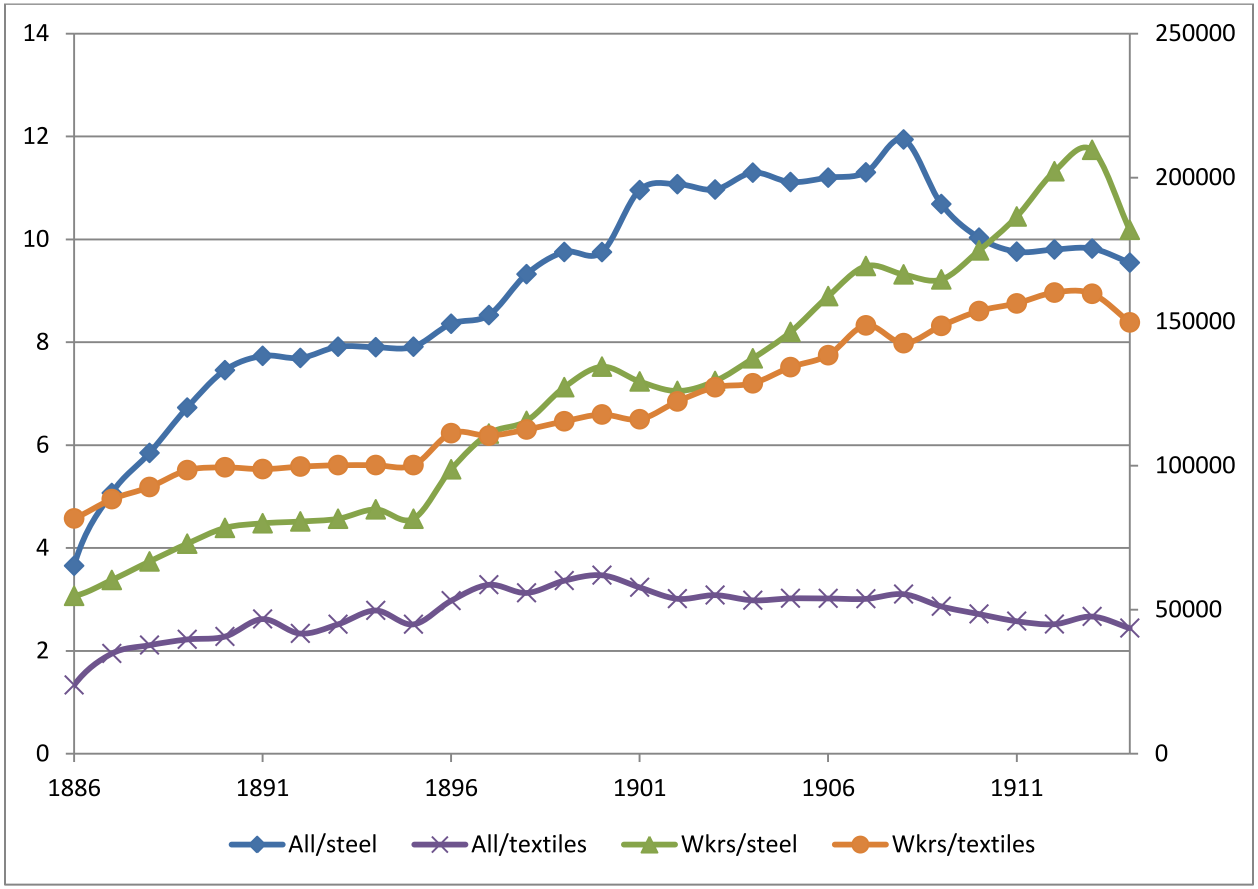
Figure 3: Accident rates for workers covered by a BGS, 1886-1914



Source: BGS database

Note: All rates expressed as number of accidents per thousand worker-years. Note that lethal accidents are plotted against the right-hand y-axis.

Figure 4: Number of workers and overall accident rates: the example of steel and textiles



Note: The accident rates plotted here are all accidents. Number of workers plotted against the right-hand vertical axis.

Appendix: First-stage regressions for IV models

	(1) Number of classes	(2) Span	(3) Enforcement
last_mean_stock	0.000764	-0.00135	0.00203
	(0.000333)	(0.000697)	(0.000788)
last_mean_fine	-8.12e-05	0.00132	0.000808
	(0.000160)	(0.000575)	(0.000388)
ins_per	0.0224	-0.176	0.177
	(0.104)	(0.0697)	(0.111)
wages_per	0.000118	0.100	-0.0864
	(0.0501)	(0.0350)	(0.0549)
year1887	-6.488	-2.534	8.358
	(15.87)	(4.277)	(6.234)
year1888	8.192	6.348	10.28
	(8.005)	(4.921)	(6.387)
year1889	-8.907	-3.110	10.51
	(8.621)	(3.783)	(4.921)
year1890	7.932	3.290	4.958
	(7.909)	(3.833)	(3.322)
year1891	-0.190	-0.360	10.21
	(8.165)	(2.099)	(2.816)
year1892	-4.483	2.097	10.19
	(8.585)	(4.678)	(3.016)
year1893	6.449	-2.652	3.371
	(8.602)	(4.149)	(3.619)
year1894	6.790	10.14	9.153
	(8.598)	(9.641)	(6.380)
year1895	-4.069	13.27	5.385
	(9.079)	(10.64)	(5.682)
year1896	5.787	5.010	10.65
	(8.971)	(7.203)	(5.423)
year1897	2.982	8.761	7.341
	(8.111)	(5.632)	(5.156)
year1898	3.297	15.23	-2.217
	(8.140)	(7.424)	(4.679)
year1899	19.76	20.22	31.58
	(11.72)	(22.32)	(17.95)
year1900	-6.523	7.899	-14.03

	(13.23)	(21.24)	(17.51)
year1901	-4.057	19.38	6.301
	(9.912)	(13.77)	(10.06)
year1902	8.433	-3.295	10.08
	(14.96)	(15.86)	(7.803)
year1903	5.544	27.40	8.471
	(8.172)	(6.001)	(2.999)
year1904	26.81	27.36	39.36
	(11.49)	(14.60)	(16.14)
year1905	-14.39	-6.386	-17.51
	(13.41)	(15.71)	(18.78)
year1906	17.52	48.01	14.94
	(13.10)	(20.39)	(18.05)
year1907	-7.599	-11.92	10.37
	(14.01)	(22.63)	(12.09)
year1908	12.07	22.52	13.80
	(8.478)	(11.44)	(6.399)
year1909	15.65	40.57	24.89
	(12.05)	(17.23)	(12.56)
year1910	10.73	54.08	-1.492
	(13.94)	(16.13)	(21.92)
year1911	16.69	5.730	23.11
	(17.87)	(20.03)	(19.75)
year1912	-0.715	19.03	13.29
	(10.11)	(21.40)	(5.961)
year1913	13.62	32.18	27.22
	(8.883)	(9.504)	(8.783)
year1914	9.304	23.32	13.20
	(7.979)	(7.511)	(6.833)
Constant	6.393	10.84	-6.520
	(7.932)	(3.174)	(4.659)
Observations	287	308	343
R-squared	0.643	0.534	0.699
Number of BGS	52	50	68

Note: Robust standard errors in parentheses. The first two variables are excluded instruments in the IV models. The observations here are tariff-period means; we can use individual year fixed-effects because the BGS used different tariff periods.