Trade Unions and Occupational Health and Safety

A dissertation presented

by

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to

the Department of Economics and Business Administration

in partial fulfilment of the requirements

for the degree of

Doktor der Wirtschaftswissenschaften

Julius-Maximilians-Universität Würzburg

Würzburg, Germany

April 2011

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Abstract

This thesis comprises three essays that study the impact of trade unions on occupational health and safety (OHS). The first essay proposes a theoretical model that highlights the crucial role that unions have played throughout history in making workplaces safer. Firms traditionally oppose better health standards. Workplace safety is costly for firms but increases the average health of workers and thereby the aggregate labour supply. A laissez-faire approach in which firms set safety standards is suboptimal as workers are not fully informed of health risks associated with their jobs. Safety standards set by better-informed trade unions are output and welfare increasing.

The second essay extends the model to a two-country world consisting of the capital-rich "North" and the capital-poor "South". The North has trade unions that set high OHS standards. There are no unions in the South and OHS standards are low. Trade between these two countries can imply a reduction in safety standards in the North, lowering the positive welfare effects of trade. Moreover, when trade unions are also established in the South, northern OHS standards might be further reduced.

The third essay studies the impact of unions on OHS from an empirical perspective. It focuses on one component of OHS: occupational injuries. A literature summary including 25 empirical studies shows that most studies associate unions with less fatal occupational injuries. This is in perfect line with the anecdotal evidence and the basic model from the first essay. However, the literature summary also shows that most empirical studies associate unions with *more* nonfatal occupational injuries. This puzzling result has been explained in the literature by (1) lower underreporting in unionized workplaces, (2) unions being more able to organize hazardous workplaces, and (3) unionized workers preferring higher wages at the expense of better working conditions. Using individual-level panel data, this essay presents evidence against all these three explanations. However, it cannot reject the hypothesis that workers reduce their precautionary behaviour when they join a trade union. Hence, the puzzle seems to be due to a strong moral hazard effect. These empirical results suggest that the basic model from the first essay needs to be extended to account for this moral hazard effect.

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Gewerkschaften und Sicherheit am Arbeitsplatz

Zusammenfassung

Diese Doktorarbeit besteht aus drei Aufsätzen, die die Auswirkungen von Gewerkschaften auf die Sicherheit am Arbeitsplatz untersuchen. Der erste Aufsatz schlägt ein theoretisches Modell vor, das die entscheidende Rolle von Gewerkschaften bei der Entwicklung sicherer Arbeitsplätze unterstreicht. Firmen sind traditionell gegen bessere Gesundheitsstandards. Sicherheit am Arbeitsplatz ist teuer für Firmen, erhöht aber die durchschnittliche Gesundheit der Arbeitskräfte und somit das aggregierte Arbeitsangebot. Ein Laissez-Faire-Ansatz, in dem Unternehmen die Sicherheitsstandards festlegen, ist suboptimal, da Arbeitnehmer nicht in vollem Umfang über die Gesundheitsrisiken informiert werden, die mit ihren Arbeitsplätzen verbunden sind. Sicherheitsstandards, die durch besser informierte Gewerkschaften festgelegt werden, steigern den Output und die Wohlfahrt.

Der zweite Aufsatz erweitert das Modell um eine Zwei-Länder-Welt bestehend aus dem kapitalreichen "Norden" und dem kapitalarmen "Süden". Der Norden hat Gewerkschaften, die hohe Sicherheitsstandards festlegen. Im Süden gibt es keine Gewerkschaften, und die Sicherheitsstandards sind niedrig. Der Handel zwischen beiden Ländern kann zu einer Senkung der Sicherheitsstandards im Norden führen, was den positiven Wohlfahrtseffekt vom Handel reduziert. Wenn nun auch im Süden Gewerkschaften eingeführt werden, dann könnte dies zur noch stärkeren Reduzierung von Sicherheitsstandards im Norden führen.

Der dritte Aufsatz untersucht den Einfluss von Gewerkschaften auf Sicherheit am Arbeitsplatz aus einer empirischen Perspektive. Er konzentriert sich auf eine Komponente von Sicherheit am Arbeitsplatz: Arbeitsunfälle. Eine aus 25 empirischen Studien bestehende Literaturzusammenfassung zeigt, dass die meisten Studien Gewerkschaften mit weniger tödlichen Arbeitsunfällen verbinden. Dies steht völlig in Einklang mit der anekdotischen Evidenz und dem Basismodell aus dem ersten Aufsatz. Erstaunlich ist jedoch, dass es – den meisten empirischen Studien zufolge – durch die Einführung von Gewerkschaften zu *mehr* nicht-tödlichen Arbeitsunfällen kommt. Dieses rätselhafte Phänomen wird in der Literatur damit erklärt, dass (1.) die Dunkelziffer der nicht-angezeigten Arbeitsunfälle in gewerkschaftlich organisierten Betrieben niedriger sei, dass (2.) Gewerkschaften sich vor allem in den Arbeitsbereichen konstituieren, in denen ein hohes Arbeitsunfallrisiko herrscht und dass (3.) gewerkschaftlich organisierte Arbeitnehmer höhere

Löhne auf Kosten besserer Arbeitsbedingungen bevorzugen würden. Mit Hilfe von Paneldaten auf der Individualebene liefert dieser Aufsatz empirische Belege gegen alle diese drei Erklärungen. Die Daten deuten vielmehr sehr stark darauf hin, dass die Erklärung im Verhalten der Arbeitnehmer zu suchen ist. Diese reduzieren ihre Vorsichtsmaßnahmen, wenn sie einer Gewerkschaft beitreten. Daher scheint ein starker Moral-Hazard-Effekt die Lösung des Rätsels zu sein. Dieses überraschende Ergebnis gibt den Anlass zu weiteren Forschungsaktivitäten. So müsste das Basismodell aus dem ersten Aufsatz nun erweitert werden, um diesen Effekt adäquat zu berücksichtigen.

Acknowledgments

This thesis was written while I was a research assistant at the Chair of International Macroeconomics at the University of Würzburg in Germany. The chair and its team provided me with excellent facilities and a wonderful research environment. I profited from stimulating discussions with my colleagues, in particular with Irene Schumm, Nicole Weschler, and Andrey Launov. I would like to emphatically thank Prof. Dr. Frank Stähler for giving me the possibility to finish this dissertation at the chair.

My greatest gratitude goes to my thesis supervisor Prof. Dr. Klaus Wälde. He guided me throughout this thesis with patience and perseverance and always tried to teach me how to do high-quality research. He is one of the few supervisors that always finds time for his doctoral students.

I would also like to thank my families in Germany and Colombia for always believing in me. This thesis is dedicated to them. I thank my wife and children for being my main source of inspiration. My wife Anja accompanied me during this long project and has always assisted me morally and intellectually. I thank my parents for their emotional and financial support during my undergraduate studies in France and Germany which brought me to the level to begin a doctoral programme. I am grateful to my father from whom I have inherited discipline, perseverance and the love for acquiring knowledge, and to my mother who taught me patience, optimism, and how to put this knowledge into practice. I thank my sister for showing me how to see things in a different way.

A mi familia

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Chapter 1

Introduction

Throughout contemporary history, trade unions have played a crucial role in making workplaces safer. In the United States for example, unions were fundamental to the development and passage of the Occupational Safety and Health Act in 1970 (Schurman et al. 1998: 134-6) and the Coal Mine Health and Safety Act in 1969 (Smith 1987). These two pieces of government legislation introduced a more comprehensive safety framework by setting stricter safety standards, allowing for safety inspections, and by requiring monetary and criminal penalties for violations. Other prominent examples of unions' safety-enhancing activities include gaining recognition for occupational diseases caused by exposure to coal dust (Smith 1987), cotton dust (Botsch 1993), asbestos (Rosner and Markovitz 1991), radium (Clark 1997), and dibromochloropropane (Robinson 1991).

In more general terms, unions have influenced occupational health and safety outcomes in several important ways. These include the provision of job hazard information, the protection of workers who refuse to accept hazardous assignments, and the assistance and representation of workers in accident compensation claims. Moreover, apart from influencing the regulatory process and its enforcement, unions bargain for the provision of protective equipment, for compensatory wages, and for the establishment of joint union-management health and safety committees (see Robinson 1991: 40, Beaumont 1983: 2, Viscusi 1979a: 230-1, Dorman 1996: 131-4, and Schurman et al. 1998).

This thesis comprises three essays that study the impact of trade unions on occupational health and safety (OHS). The first essay in **Chapter 2** introduces a theoretical model to the literature that allows to study unions' safety activities. This contribution is important since the theoretical literature has largely ignored OHS activities of unions and has mainly focused on the impact of unions on wages, employment, and fringe benefits.

The model seeks to condense the main costs and benefits of better OHS measures. On the one hand, OHS measures are costly to implement as they reduce the total factor productivity (TFP). Because of these costs, firms traditionally oppose better safety measures. On the other hand, better OHS standards lead to an increase of the average health of workers, increasing aggregate labour supply. There is thus a trade-off at the aggregate level of better safety measures between lower TFP and higher aggregate labour supply.

The model studies two possible scenarios of implementing OHS measures. In the first scenario (laissez-faire scenario), there are no trade unions and firms are allowed to set safety standards unilaterally. The results show that the laissez-faire allocation is suboptimal since workers are not fully informed of the risks associated to their jobs. The average health of workers, and thereby the aggregate labour supply, is too low.

The second scenario studies the impact of OHS measures set by trade unions. In this scenario, it turns out that unions are able to balance the positive effect on the improved health of their members with the negative effect of firms' lower labour demand due to lower TFP. If unions are not too extreme in their safety preferences, higher OHS standards than in the laissez-faire scenario increase economy-wide output and welfare. The presence of unions in the model is welfare-increasing. The reason is that unions are better placed to providing and confirming information about the health effects of working. An individual worker does not have enough time and makes too few observations to discern job-related health effects from other health effects. A union has many members and thereby more observations. Learning is much faster. Moreover, unions have the political power to impose better safety measures.

The second essay in **Chapter 3** extends the basic model to a global framework. This extension is important since it allows to study the impact of globalization on OHS. In fact, the international trade literature has so far mainly focused on the impact of globalization on wages, employment, and, more recently, on cultural issues. The impact of globalization on labour standards (except for the impact on child labour) has been largely ignored. All this despite a widespread public perception in industrialized countries that globalization can lead to a deterioration of labour conditions. The contribution of this chapter is to extend the model from Chapter 2 to a two-country world to study the impact of globalization on OHS standards.

In the model, the two countries are labelled as "the North" and "the South". These two countries are exactly the same except that the North is capital rich and has trade unions that set high OHS standards. The South is capital poor and OHS standards are low because there are no trade unions there. The model studies the welfare effects if these two countries open up their borders to international trade in the final homogenous good and capital.

It turns out that capital flows from North to South until its marginal productivity is equal in both regions. As in traditional factor movement models, the impact of globalization due to a better capital allocation (the capital-allocation effect) is welfare increasing for both regions. However, since the capital stock in the North is reduced, workers' wage income decreases, and unions react by reducing their demands on high OHS standards (the OHS effect). This has a negative effect on welfare in the North.

The model then studies the welfare impact if trade unions are also introduced in the South. The first consequence is that southern unions increase safety levels in the South. This improves southern welfare as in the autarky model from Chapter 2 but it also implies an increase in the marginal productivity of capital in the South. This leads to even more capital flowing from North to South. The impact of globalization due to better capital allocation is also unambiguously positive in both regions. In the North, however, unions set even lower OHS standards, further reducing northern welfare. In the South, the higher capital stock implies that unions increase southern OHS standards, magnifying the positive impact of globalization on southern welfare.

In more general terms, the model finds that bringing down the trade and FDI barriers has a clear positive allocative welfare impact, as in traditional trade models. The impact on labour conditions, however, is positive only for countries that can attract capital inflows and, more importantly, for countries that have an institution, like trade unions, that can "extract" better working conditions from this additional capital. The model suggests that globalization is a win-win situation for the South. In the North, globalization leads to a welfare improvement only if the capital-allocation effect is bigger than the negative OHS effect.

The third essay in **Chapter 4** explores the effects of unions on OHS from an empirical perspective. The focus is on one aspect of OHS: occupational injuries. The essay begins by summarizing 25 empirical studies investigating the impact of unions on occupational injuries. Two main results emerge from this summary. First, most studies suggest that unions are effective in reducing fatal occupational injuries. This is in perfect line with the anecdotal evidence and the basic model in Chapter 2. The second result is that most empirical studies associate unions with *more* nonfatal occupational injuries. This is a result that has puzzled researchers for more than three decades since it clearly contradicts expectations based on anecdotal evidence and on unions' activities. Moreover, the essay presents new estimates using individual panel data for the first time that confirm and reinforce this paradoxical result. The estimates indicate that union members are at least 29 % more likely to have a nonfatal occupational injury than their nonunion counterparts.

The objective is then to try to understand why unionized workers are more likely to have a nonfatal occupational injury. This puzzle has been explained in the literature by (1) lower underreporting in unionized workplaces, (2) unions being more able to organize hazardous workplaces, and (3) unionized workers preferring higher wages at the expense of better working conditions. Surprisingly, apart from suggesting these explanations, the literature has been very limited in providing empirical evidence supporting or rejecting them. Using panel data from the National Longitudinal Survey of Youth 1979 (NLSY79), the essay finds very little empirical evidence for these explanations employing standard econometric methods.

However, the anecdotal evidence and the new estimates using panel data point to a different explanation for the paradox: moral hazard. Other authors like Viscusi (1979b), Rea (1981), Carmichael (1986), and Lanoie (1991) have already argued before that workers themselves might offset the benefits of a safer work environment by diminishing their own safety-enhancing efforts. This argument is extended by suggesting that it is trade unions that provide or bargain for the safer work environment. The increased safety and protection that unions provide enhance workers' feeling of safety, leading workers to adapt their behaviour, for example, by working faster, becoming bolder, or by taking less safety precautions. This riskier behaviour more than offsets the union safety efforts by increasing the likelihood of a nonfatal injury.

The panel nature of the NLSY79 data set is exploited to provide evidence for the moral hazard explanation. Some of the key results are: The injury probability of a worker increases after one period of unionization, although this increase is not statistically significant. After two periods of unionization, the injury probability increases further, and in this case, the increase is significant. This suggest that workers need some time to adapt to the new safety and protection offered by unions before the moral hazard effect becomes relevant. Moreover, the results also show that when the union protection is over, the moral hazard effect disappears. In fact, the essay finds that workers that quit unions experience an immediate reduction in their injury probability.

This thesis represents one step ahead in understanding the complex relationship between unions and OHS. However, some questions still remain open. In particular, more research is necessary to understand why the empirical literature associates unions at the same time with less occupational fatalities but also with more nonfatal occupational injuries. This is a pattern that has also been found in the workers' compensation literature. In fact, the evidence from this literature shows that workers' compensation is encouraging *more*, not less, nonfatal injuries but seems to be reducing fatalities (Moore and Viscusi 1990, ch. 9, Ruser 1993). The answer might be that the moral hazard effect is less pronounced for very severe injuries. Concerning unions and OHS, the next step could be to extend the basic model from Chapter 2 to account for this moral hazard effect. This might be an important step towards a complete theory of the impact of unions on OHS.

Chapter 2

How trade unions increase welfare[1]

2.1 Introduction

The process of economic development and growth is a process of an endless introduction of new technologies. This is especially true for the early stages of the Industrial Revolution but also applies today. When new technologies are introduced, their properties are not always well understood. While a technology might promise that a certain good is provided very efficiently, the same technology could also have side effects that did not occur to the inventor. The history of the introduction of new technologies is full of countless examples.

Since as early as the Roman Empire, coal has been used as a source of energy. Systematic coal mining, however, was not carried out until the Industrial Revolution, when a massive and steady supply of energy was required. Coal seemed like the perfect solution. Mining, however, has its side effects. In 1831, a potential causal link between working in a coal mine and black lung disease was first reported by a Scottish physician. Nowadays, black lung disease is accepted as a disease caused by the repeated and year-long inhalation of small amounts of coal dust. However, it took more than 130 years for this link to be generally accepted. Only in the 1960s, after extensive political activities by various worker groups in Pennsylvania, Ohio, and West Virginia on the Appalachian coal fields, was black lung disease recognized as an occupational disease. As a consequence, the Coal Mine Health and Safety Act was passed in 1969 which established more comprehensive rules for work conditions and also the compensation of disabled mine workers (Smith, 1987).

There is an abundance of further examples of worker movements improving health and safety conditions, including "brown lung" disease caused by exposure to cotton dust (Botsch, 1993),

[1] This chapter is joint work with Klaus Wälde and appeared as Donado and Wälde (2010b).

"white lung" disease caused, inter alia, by mining and the exposure to asbestos (Rosner and Markovitz, 1991), the health risk posed by radium (Clark, 1997), workplace exposure to dibromochloropropane, a pesticide that makes workers sterile and is linked to the risk of cancer (Robinson, 1991), the spray machine conflict in the early 1900s (Frounfelker, 2006) or conflicts in the pottery industry (Stern, 2003) and in the automobile and steel industries (Bacow, 1980, ch. 5). For an overview of the literature on the history of occupational health and safety (OHS), see Judkins (1986, p. 240). A more general history of labour standards with international comparisons is covered by Engerman (2003).

A reading of these analyses shows that the side effects caused by new ways of production reveal themselves only gradually. While there might be uncertainty about health implications of a certain job, there is initially often simply ignorance about health implications, sometimes just absence of any doubt. When workers then start sensing that "something is going wrong", that work conditions are causing health problems, these claims are often met with doubt, not only by employers, but also by insurance companies or even the government. These analyses also clearly demonstrate that worker movements, joint collective actions by individuals, are required to raise political awareness, to lobby for changes in work conditions and to eventually bring about regulatory changes towards better OHS measures.

Similar conclusions about the importance of worker movements for triggering broader support not only for the improvement of working conditions but also for the development of the modern welfare state can be drawn when looking at Germany. During the Industrial Revolution around 1850, the issues of poverty, working and living conditions of dependent workers caused organizations to be created enabling workers to express their own interests (see e.g. Schneider, 2005, p. 15). While poverty and dependent work also existed in pre-industrial times, the contemporaneous rise of the wealthiness of some and the poverty of others was no longer accepted as "the will of God". The first trade union in Germany, founded in June 1848 by type setters, was set up with an aim to secure the living standards of type setters, who feared competition from the steam engine and technological progress (hence, there was income orientation), but also with an aim to establish mutual health and disability insurance systems (Schneider, 2005, p. 27). The worker movement, represented by unions and political parties, was also incited by occupational injuries which almost caused "mass causalities" (Tennstedt et al. 1993, p. XXI), partly due to the widespread use of new technologies and fast economic growth. These movements and associated political pressure caused Bismarck, the German chancellor, to implement, inter alia, statutory accident insurance in 1884.

The outcome of this discussion about historical episodes in advanced OECD countries is threefold: (i) A safe workplace, in short OHS, does not come for free: Achievements of the modern welfare state, which today are taken for granted, were hotly disputed in the past. (ii) There is a conflict of interest between unions and firms, which goes beyond pure wage bill issues. In many cases, industry, insurance companies and often also the government initially object to any demands for compensation or changes in health standards simply because there is no clear scientific medical evidence for the claimed nexus between certain symptoms and the professional activity. (iii) Unions[2] played a crucial role in pushing for OHS standards and prepared and fought for what is (almost generally) accepted today as a positive aspect of modern welfare states (see e.g. Brugiavini et al. (2001, ch. II.2.1), Agell (1999, p. F144) and the discussion below). Only once workers succeed in forming large groups and in lobbying for their joint interests is there enough political visibility in order for changes in OHS regulations to take place. To put it briefly, in the spirit of Freeman and Medoff's (1984) "collective voice": Trade unions have a "good face" as well.

The purpose of this chapter is to understand why it took worker movements (rather than the government or employers) to start the development of insurance mechanisms. Why did worker movements eventually lead to the creation of government agencies which regulate OHS nowadays and what are the determinants of endogenous OHS standards?

We shall construct a model which highlights the key ingredients for understanding the importance of worker movements in the past. Jobs have two effects on workers - they provide income and they affect health. In order to keep the analysis as simple as possible, we will assume that workers are entirely ignorant about the health implications of jobs: job choice is based purely on the wage paid by the employer. Returning to the coal miner example from above, workers were simply not aware of the potential risk of black lung disease.[3] We consider an economy with one homogenous good and assume perfect competition on goods and labour markets, implying, inter alia, full employment. Unions do *not* cause unemployment in our setup. Given the absence of any information on the health risk of working, the production process exerts a negative externality on workers' health. OHS standards can in principle reduce this negative externality but they also reduce the total factor productivity (TFP) of firms, reflecting the fact that OHS is costly. As long as health effects of working are disputed, no employer or government would concede better working conditions.

[2] We will often use 'union' as name for more informal worker groups, worker movements or worker associations. Union, as used here, does not necessarily describe a well-organized and at times bureaucratic institution as is nowadays the case in some OECD countries.

[3] We see this complete ignorance as a short-cut to a Bayesian learning setup where workers form a prior about health implications and it takes time to learn the true health consequences of a job. See Viscusi (1979c, 1980) for various applications of Bayesian learning to uncertainty about health implications of jobs.

The role of worker movements is to provide and confirm information about the health effects of working. An individual worker does not have enough time and makes too few observations to discern job-related health effects from other health effects. A group of workers, a union, has many members and thereby more observations. Learning is much faster and unions can thereby help internalize the externality.

In standard trade union models, the objective of trade unions is to maximize the wage income of their members. We extend this arguably narrow perspective and portray trade unions as having both high wage income and good health standards as their objective. We then find determinants of OHS standards by letting unions set OHS standards. This monopoly view of OHS-setting unions and employment-setting firms is - as in wage-setting models of unions - a short-cut to a more complete setup with endogenous union membership where workers form groups to increase the speed of learning.

Some of our findings are as follows: Each firm individually is opposed to higher OHS standards as they reduce TFP and thereby profits. Unlike compensating differentials setups with complete information, competitive markets here are unable to take health effects caused by technologies into account: individuals can not judge with sufficiently high precision to what extent a certain job will affect the health. The laissez-faire factor allocation is characterized by inefficiently high sickness leaves. If better-informed firm-level trade unions set OHS standards, the positive effect on the improved health of their members balances the negative effect of lower employment due to lower TFP. If there are economy-wide or occupational unions, OHS standards are more comprehensive as unions also take the negative health effect on overall labour supply into account. If unions are not too extreme in their health preferences, higher OHS standards than those favoured by firms increase economy-wide output and increase welfare. The presence of unions is welfare-increasing.

Capital owners favour higher OHS standards than individual firms.[4] Capital owners see that an economy-wide improvement in health increases labour supply and thereby returns to capital owners - as long as the positive health effect is not overcompensated by the negative TFP effect. Capital owners might even favour higher OHS standards than firm-level unions. However, capital owners could never be at the origin of improving work standards as they simply do not feel (in the literal sense of the word) health effects. They have no incentive to form "capitalists' movements" as bad working conditions do not affect them. When we compare capital owners to economy-

[4]Capital owners here and in what follows denote a federation which represents the joint interest of capital owners in an economy. Individuals looking only at capital income in one specific firm would never agree on higher OHS standards.

wide unions, unions desire higher OHS standards as they value health per se (capital does not become sick but workers do). Hence, both at the firm level and at the economy-wide level, there is conflict of interest between unions on the one hand and firms and capital owners, respectively, on the other. But for a certain range of OHS, unions and capital owners agree on increasing OHS standards. This explains why - after some initial historical dispute and controversies over OHS standards - most OHS standards in OECD countries are no longer hotly disputed today.

2.2 Related literature

This chapter is related to various strands of literature. First, there is obviously a huge literature on trade unions, and it would be impossible to provide a summary here which does any justice to the various substrands. While it seems fair to argue that most contributions attribute a distorting (efficiency-reducing) role to unions[5], there are also some economists that find positive aspects in union behaviour: Brugiavini et al. (2001, ch. II.2.1) see unions as the precursor to the modern welfare state. They write on p. 163 that "unions developed mutual insurance as part of associational self-help to compensate for the lack of private insurance or public social protection. At the same time, they mobilized [...] for the expansion of social rights. Increasingly, many of the protective functions that unions provided [...] came to be taken over by the state".[6] A by now well-accepted argument was made by Freeman and Medoff (1984): By providing a "collective voice", unions provide information which otherwise would not be available. Malcomson (1983) argues that unions increase efficiency as they improve the allocation of risk-bearing between firms and workers. Acemoglu et al. (2001) argue that unions induce training and provide insurance and Boeri and Burda (2009) show that workers prefer collective bargaining in the presence of market imperfections. Booth and Chatterji (1998) and Viscusi (1979a, ch. 11) show how trade union bargaining with monopsonistic firms increases social welfare and Agell (1999, p. F144), more generally, argues that "certain institutions may serve quite useful purposes" in the labour market. We put forward OHS standards as an example of such a useful institution. We believe that this beneficial historical aspect of worker movements for what are now modern societies and the role unions can play in developing countries today has not received sufficient credit so far. Our contribution lies in the emphasis and analysis, in the framework of a very simple model, of

[5] Distortions can have their positive sides in second-best worlds or when it comes to collecting rents. See Mezzetti and Dinopoulos (1991) for an example with an employment-oriented union in an international trade setup with imperfect competition.

[6] Historical evidence linking union growth to their provision of insurance (strikes, unemployment, sickness, burial cost) for the Netherlands and Britain is provided by van Leeuwen (1997). Quantitative evidence for the United States for union decline due to an expanding welfare state is provided by Neumann and Rissman (1984).

the informational and learning advantage of a union in a world with incomplete information and side effects caused by new technologies.

Second, and maybe most importantly, our view of multi-feature workplaces is related to but differs starkly from the equalizing differences approach of Rosen (1974, 1986). Equalizing differences are traditionally derived in setups with perfect information. When workers know about all job characteristics and all markets are competitive, factor allocation is efficient and any institution would be distorting. Given the historical situation and technological examples we have in mind, workers having perfect information does not appear to be a realistic assumption. We therefore choose the other extreme and assume that workers are unable to learn anything about work-related health implications. While the reality certainly lies somewhere in-between, the justification for our assumption is simple: When new technologies become available, workers and often society as a whole do not know a lot about potential side effects. Health implications may only become apparent over the long-term and workers might simply not have the time to learn about these implications. Hence, with regard to learning processes which take a very long time, we assume right away that it is impossible for the individual workers to learn of health effects. As a consequence, a decentralized factor allocation is inefficient. In contrast, trade unions consisting of a large number of workers have access to many observations about jobs, can collect this information and can therefore learn more easily. In fact, we assume that unions have perfect information and can therefore internalize externalities, increase efficiency, output and welfare.

Finally, the rapidly growing literature on child labour touches upon some aspects covered here. For example, Doepke and Zilibotti (2005) analyse how attitudes towards child labour regulation can change over time. Baland and Robinson (2000) derive determinants of child labour and generally find that child labour is inefficient. In contrast, Krueger and Donohue (2005) find that a child-labour ban is not necessarily welfare-increasing. To the extent that child labour is bad for the health and safety of children, our analysis implicitly studies the effects of trade unions on child labour. In fact, Doepke and Zilibotti (2005, p. 1494) mention that the "trade union movement played a key role in lobbying for the introduction of child labour regulation". Baland and Robinson (2000, footnote 17) make a similar point. This literature, however, does not focus on unions as an institution as we do here and does not attempt to work out the potentially beneficial effects unions and their use of their market power can have. Chapter 3 studies the effect of globalization for labour standards in the North and in the South in the presence of unions as portrayed here.

2.3 The model

Our economy produces a homogenous good. Aggregate output amounts to Y. A typical firm produces the quantity y by employing capital k and labour l, the latter of which is measured in working hours. All firms use the same technology with TFP $A(s)$,

$$y = A(s) f(k, l), \tag{2.1}$$

where capital and labour inputs have the usual neoclassical effects on output. Given our historical perspective on what are now OECD countries or our focus on developing countries today, we assume that firms can hire from a spot market. There are no hiring or firing costs and it does not take any time to find a worker.

The central focus of this chapter is OHS. This aspect is reflected in the production process in the TFP component $A(s)$. TFP in a firm or in a country is influenced by many factors, starting from very technology-specific aspects (like the age distribution of the capital stock or the management and communication skills of staff) and ranging to more economy-wide influences (like the institutional stability, the political regime, or the education level of workers). The more important factor influencing TFP for our arguments is OHS s. A job is safe(r) if a worker is (more) certain to return home in good health after 8 (or more) hours of work. We reflect safer jobs by a higher $s > 0$.

Safe workplaces are clearly in the interest of the worker, and in many cases, OHS is also a central concern for employers. If safety measures increase the smoothness of a production process, employers should be in favour of high safety standards. An accident in a coal mine, costing not only lives of workers but also letting the production process break down for weeks, is clearly not in the interest of the firm. In many cases, however, there is a fundamental conflict of interest. In the case of low-skill workers or workers needing only general (i.e. not firm-specific) human capital to perform their job and in countries where firms do not (have to) pay sickness-leave (i.e. whenever firms can easily replace their workers), firms have no economic interest in the state of health of their workers. Quite to the contrary, OHS measures are costly. A workplace where coal miners are well protected against black lung disease or ore miners against silicosis is more costly than one without protection measures like ventilation systems. A worker who spends half an hour dressing and undressing (helmets, safety glasses, gloves, entire suits etc.) is less productive than a worker who starts doing his job right away.

What matters for our results is that workers value safety more than firms. For modelling purposes, we go to the extreme and exclude firms from any benefits from higher safety. We capture safety costs by letting OHS measures reduce TFP, $A_s < 0$ (subscripts denote partial derivatives).[7] Given the spot market assumption, a sick worker would simply be replaced by a new healthy worker.

An individual values consumption c and health z and both are determined by the job an individual chooses. A job is therefore a differentiated good as in Rosen (1974). Let $z(s,m)$ denote the share of potential working hours that an individual is healthy and can work. Currie and Madrian (1999) summarize the literature on health and labour markets. They document a positive relationship between health and income with health having a larger effect on hours than on wages. While it is true that the link between health and labour market participation is less clear-cut (Currie and Madrian stress that this could be due to an abundance of methodological problems), in the following we feel safe to assume that longer working hours m under bad OHS standards are bad for health, $z_m < 0$, but safety measures s improve health, $z_s > 0$. Utility of workers increases in consumption c and health $z(s,m)$ but with a decreasing slope, $u_c > 0$, $u_{cc} < 0$ and $u_z > 0$, $u_{zz} < 0$. Letting all individuals work the same number of hours m, we can suppress m and use

$$u = u(c, z(s)) \tag{2.2}$$

as utility function. Health is important for two reasons: It matters per se and consumption rises due to longer hours worked. All workers are identical in their preferences.

On the aggregate level, consumption equals output $C = Y$ and labour demand L equals labour supply,

$$L = z(s)N. \tag{2.3}$$

The latter is given by potential employment N (also measured in hours and assumed to be fixed) multiplied by the share $z(s)$ of time workers are healthy and can actually work. Improved safety, implying improved health, implies higher labour supply.

We finally turn to trade unions. Depending on the degree of centralization of negotiations and wage setting, the literature usually classifies countries in three groups (see e.g. Calmfors and Driffill, 1988): (1) highly decentralized systems with wage setting at the firm level (i.e. USA and Canada), (2) intermediate degree of centralization (most continental European countries), and (3) highly centralized systems with wage setting at the national level (i.e. Nordic countries

[7] This is the standard assumption in the literature on compensating differentials, see e.g. Rosen (1986). If A increased in s, no uncertain jobs would ever be observed. One can always imagine that A initially increases in s but decreases above some threshold level. It could be that low s reduces labour productivity rather than TFP. For simplicity, we will continue to use the term TFP.

and Austria). We will also consider different degrees of centralization and model the two polar cases of highly decentralized and highly centralized systems.

In a decentralized setup, unions operate at the firm level and are therefore small in comparison to the economy as a whole. As we view spot markets as the best description of labour markets for activities as described in the introduction, there is no attachment of workers to the firm. Hence, membership of firm-level unions is just as volatile as employment at the firm. As a consequence, the union only cares about the overall well-being of the l workers in this particular firm. As households value consumption and health, we let unions value these quantities as well. Consumption depends on capital and labour income and union members might also have some capital income. Observing union activities, however, we find it more appropriate to model unions as institutions which focus on labour income or the employment situation in general. Unions neglect the capital market position of their members and focus on the wage sum of their members. Given historical examples about union behaviour in now OECD countries and preferences of households in (2.2), unions also care about a worker's health and a union's utility function reads

$$v = v\left(wl, z\left(s\right)\right), \qquad v_{wl} > 0, \qquad v_z > 0. \tag{2.4}$$

Labour income wl of union members depends on the market wage w and on labour demand l as chosen by the firm. Depending on the importance attached to each of these two objectives, the union might be called income-oriented or health-oriented.[8]

In some countries, unions are large or form a confederation. Their basic objectives are the same but they now represent not only the workers of a particular firm but the whole labour force,

$$V = V\left(wL, z\left(s\right)\right), \qquad V_{wL} > 0, \qquad V_z > 0. \tag{2.5}$$

The main difference compared to the firm-level union is that health now has two positive channels, as in individual preferences (2.2): health matters per se and through higher labour supply visible here through L. An alternative to economy-wide unions, also captured by (2.5), are occupation-specific unions. As long as a union takes the effect of standards on all workers into account (e.g. because a union represents all coal miners and not just those currently employed in one particular firm), beneficial labour supply effects as a result of higher standards are internalized by the union.

[8] For an introduction to the discussion on the appropriate specification of union preferences, see Oswald (1982) and Booth (1995, ch. 4). Note that even for modern Britain, there is evidence that physical working conditions is one important issue over which trade unions and management bargain (Millward et al., 1992, pp. 249-254).

2.4 Centralized and decentralized OHS setting

This section explores the behaviour of a planner and OHS levels in a decentralized economy. This allows us to understand the basic mechanism of why trade unions in principle can have positive welfare and output effects.

2.4.1 The planner

As all firms use the same technologies, we can simply insert aggregate capital endowment K into (2.1). After also inserting the labour-market equilibrium condition (2.3), total output is given by

$$Y(s) = A(s) f(K, z(s) N). \tag{2.6}$$

Welfare comparisons require a social welfare function. With identical preferences and homogenous firms, all workers will be equally healthy. The only source of heterogeneity of households could be wealth holdings. However, as our static framework is agnostic about wealth distributions, we will work with the assumption of a representative consumer. We can therefore use the individual utility function (2.2) and obtain a social welfare function by inserting aggregate consumption,

$$U(s) = U(C(s), z(s)) = U(Y(s), z(s)). \tag{2.7}$$

A social planner maximizing social welfare (2.7) chooses a safety level s^U that satisfies (see app. A.1.1)

$$\varepsilon_{UY}\varepsilon_{YA}\varepsilon_{As} = [\varepsilon_{UY}\varepsilon_{YL} + \varepsilon_{Uz}]\,\varepsilon_{zs}, \tag{2.8}$$

where, for readability, all elasticities throughout this chapter are defined as positive quantities. Hence, the OHS elasticity of TFP and the inverse wage elasticity of labour demand require a minus sign in their definition,

$$\varepsilon_{xg} \equiv -\frac{\partial x}{\partial g}\frac{g}{x}, \quad \text{for} \quad xg \in \{As,\ wL\} \qquad \text{and} \qquad \varepsilon_{ad} \equiv \frac{\partial a}{\partial d}\frac{d}{a} \qquad \text{for} \quad ad \notin \{As,\ wL\}. \tag{2.9}$$

Condition (2.8) balances the welfare-increasing and welfare-decreasing effects of increased safety. The left-hand side captures the cost of increased safety caused by a lower TFP: A one-percent increase in the safety level reduces the TFP and thereby output by $\varepsilon_{YA}\varepsilon_{As}$ percent. Multiplying this with the output elasticity of welfare, ε_{UY}, yields the percentage reduction in welfare. For maximum welfare, this negative effect of increased safety has to be equal to the positive effect on the right-hand side. A one-percent increase in safety increases the share of time working by

ε_{zs} percent. This gives, multiplied by ε_{Uz} and by $\varepsilon_{UY}\varepsilon_{YL}$ respectively, the percentage increase in utility caused by better health and higher income.

If the planner focused only on output maximization (that is, if $\varepsilon_{Uz} = 0$), the optimality condition giving the output-maximizing safety level s^Y would read

$$\varepsilon_{YA}\varepsilon_{As} = \varepsilon_{YL}\varepsilon_{zs}. \qquad (2.10)$$

This condition balances the output-decreasing effect on the left-hand side with the output-increasing effect on the right-hand side. Interestingly, one can prove that for the general production function in (2.6) the welfare-maximizing safety level is always higher than the output-maximizing safety level, $s^U > s^Y$.[9]

2.4.2 The decentralized economy

The standard view to a setup with multiple job characteristics is Rosen's (1974, 1986) equalizing-differences approach. According to this approach, workers enjoy (or dislike) job characteristics in addition to the wage and a worker's utility function would look like the one we use in (2.2). The difference to our approach consists in the criteria for choosing a job. In the equalizing-differences approach, workers have full information about job characteristics and the choice of jobs would depend both on health implications $z(s)$ and on income leading to a consumption level c. Firms can therefore choose wage-safety pairs on a worker's indifference curve. The resulting market equilibrium would be efficient.

The crucial difference from our approach lies in our historical perspective of unions in contemporary OECD countries and the conclusions we draw about information. Workers do not have sufficient information (neither would society as a whole) to perfectly evaluate the impact of work, a certain job or a specific technology on health. Workers could form expectations but their expectations need to be - in the absence of perfect information - based on a prior in a Bayesian learning sense. Perfectly competitive firms taking a safety-wage trade-off into account would then set an inefficient safety level if the prior is not identical to the true distribution of the health impact of a job. When on the job, workers would of course gradually learn about health implications of work, but each single worker makes just a few observations, especially when health

[9] Intuitively, the proof (see app. A.3.1) runs as follows: Let s maximize output in (2.6). Now add health to this objective function and obtain (2.7). As the health term monotonically increases in s, a somewhat higher health level is better as a marginal increase in health does not reduce output at $s = s^Y$ but does increase the health term. Hence, $s^U > s^Y$. Clearly, how much s^U exceeds s^Y depends on how strongly health is valued, how strongly health increases and how fast output drops when s increases.

also depends on other factors than just work and certain health impacts come with a long delay or can not easily be observed (as the examples in the introduction have shown). There is simply not enough variation; econometrically speaking, there is not a sufficient number of observations to draw firm conclusions and learning can take more than a lifetime. To capture this idea in the simplest way possible, we assume here that workers choose employment based only on the wage and firms choose employment taking the wage rate as given. This will qualitatively imply the same type of inefficiency one would observe in a Bayesian setup (as employed e.g. by Viscusi, 1979c, 1980). The advantage of this shortcut is clearly the much simpler analytical tractability.

Given this focus of workers on wages (and capital owners on returns), optimal firm behaviour yields the familiar equality between marginal productivities and factor rewards,

$$w = A(s) f_l(k,l), \quad r = A(s) f_k(k,l). \tag{2.11}$$

In a laissez-faire economy, a firm fixes, in addition to the stock of labour and capital, the safety level s. The derivative of profits with respect to the safety level is $d\pi/ds = A_s$, i.e. it is negative. Firms only see the TFP-reducing impact of increased safety. As a consequence, firms would like OHS standards to be as low as possible.[10] The comparison point to the central planner solution s^U or s^Y is a laissez-faire safety level of s^π. Given that we exclude negative safety levels, we can set s^π to zero (or to the level where $A(s)$ starts to fall, see fn. 7). The resulting equilibrium is clearly inefficient.

2.4.3 Capital owners

Given the assumption of a representative consumer discussed before (2.7), one could wonder why there should ever be a conflict of interest in this economy. We see the representative consumer assumption as a convenient shortcut which allows us to work with a social welfare function (2.7) that abstracts from the distribution of wealth. We nevertheless look at two types of institutions: trade unions and a federation of capital owners. These institutions represent interests as if their members received only labour income or only capital income. A more "realistic" model would include a distribution of wealth and would thereby justify endogenously conflicting interests. The conclusion one would draw concerning optimal safety levels for capital and labour would be identical, as we now see.

[10] The same would be true for small "entrepreneurs" who invest in their own firm. Someone owning k in a firm and calculating the safety level which maximizes rk would also find that it is optimal to reduce s as much as possible.

Let us compare the firm safety level to one which would be set by a federation uniting all capital owners in an economy. At the country level, the safety level s^R that maximizes total capital income $r(s)K$ is described by (see app. A.1.5)

$$\varepsilon_{rA}\varepsilon_{As} = \varepsilon_{rL}\varepsilon_{zs}, \tag{2.12}$$

where again the elasticities are defined as in (2.9). Here, capital holders do not only consider the TFP-reducing impact (on the left) but also the health-increasing impact (on the right) of increased safety. The reason for this is that interest rates depend on output, and, as we have already seen, output can be increased by improving the workers' health in a country.

The safety differences between the planner, the firms and capital owners highlight the externality caused by the production process. If the planner focused on TFP only, as does each firm, OHS s would be as low as possible since this increases output (2.6). A low safety level, however, decreases the share $z(s)$ of time a worker is healthy and can work. This reduces aggregate labour supply $z(s)N$ and therefore output (2.6). Hence, the starting point of our analysis of the effects of union activity is a second-best world where production exerts a negative externality on health. Output in a laissez-faire economy is inefficiently low and adding an institution - in our case a union - that sets OHS standards can improve efficiency.

2.5 Endogenous OHS with trade unions

The previous section explored the effects of the negative production externality. We will now show that if trade unions are introduced, the distorting effect can be reduced or even eliminated. Why does the union have the knowledge and means required to do so? There are two reasons: First, unions have many members and the more members there are, the easier it is to learn about a job situation. Due to its size, the union can collect information more easily than individuals. Second, in contrast to a loose group of workers that have no institutional connection, unions have the means to "prove" the link between bad work conditions and health. They can monitor the credibility of individual claims about work conditions more easily[11] and they also have the power to impose better working conditions. Unions are a means to overcome the information and credibility problem of individual workers (see, for example, Fenn and Ashby (2004, p. 46)

[11] The importance of unions in alleviating moral hazard problems has already been stressed by Beveridge in 1909 (quote taken from van Leeuwen, 1997, p. 786). Beveridge claims that unions of his time were in the best position to monitor the appropriate use of unemployment benefit payments.

and Robinson (1991, pp. 41-7)).[12]

We will first analyse the principles of optimal union behaviour in a general setup. We compare the implied safety levels with those optimal for capital owners. This allows us to see under which conditions and to which extent there is a conflict of interest between unions and capital owners. We will then look at various examples (with Cobb-Douglas (CD) and CES production and utility functions) to reveal the precise determinants of welfare gains and potential conflicts of interests. This will show the potential but also the limits of union activity on social welfare. We will consider a decentralized system (firm-level unions) and a centralized system (trade union confederation).

2.5.1 The general case

- Firm-level unions

In basically all OECD countries, today and in the past, unionised and non-unionised sectors coexist. Union densities change over time and sometimes unionized firms compete with non-unionized firms. Various explanations can be offered for both the coexistence and varying union densities. In a competitive setup à la Rosen with heterogenous firms, one can imagine that firms offering the more dangerous jobs are unionised while others are not. In the theoretical literature on "deunionisation", Acemoglu et al. (2001) show how biased technological change can be the reason for both deunionisation and an increase in wage inequality. In their setup, workers have an explicit choice whether to unionize or not.

We abstract from these important issues as we want to compare our approach to the canonical model of trade unions. In the traditional monopoly union model (see Dunlop, 1944, Oswald, 1982), unions set the wage, firms choose employment and unemployment is the inefficient equilibrium outcome. We give unions market power as well, assuming that it is beneficial for workers to join a union and that unions succeed in learning about the work-health link better than workers and unions succeed in solving the monitoring problem.[13] This is our highly condensed version of historical processes: Historically, worker movements do not have any market power when they start. Political parties are often the vehicle through which public attention and support increase.

[12] Firms can also learn faster than individual workers as a firm hires many workers. Once the firm has learned about negative health effects of a certain technology, however, it might not be in the firm's interest to reveal this information as workers with health problems that were incurred in the past could then file claims.

[13] Giving unions market power allows us to use the elegant monopoly union setup. This should not suggest, however, that we make a second-best world argument where one distortion (the market power of unions) corrects for another distortion (imperfect knowledge). Unions are beneficial even without (or despite) market power as they provide a superior (collective) learning technology in comparison to individualistic learning. Future work could use a Bayesian learning setup where collective information collection alone improves welfare.

If new regulations then improve OHS standards, they are put into force by the government. Indirectly, however, these new regulations are set by worker movements and this is what we capture here. Unions use their market power not to set wages - as in the traditional model - but to set the safety level s. While unions in the real world are concerned with several issues of which wage negotiation is an important one, we focus here entirely on union activities related to improving work conditions as described in the introduction. Wages are perfectly flexible in our setup and there is no unemployment.

At the firm level, employment l in the union's objective function (2.4) is given by the firm's labour demand from (2.11) which, through TFP, is a function of the safety level, $l = l(A(s))$. The wage rate w and the firm's capital stock k in the labour demand function $l(\cdot)$ are taken as parametric by the union. The choice of the safety level s^v is perceived by the union to affect labour demand through TFP and health $z(s)$. Assuming an interior solution, the first-order condition of maximizing (2.4) subject to $l = l(A(s))$ is given with (2.9) by (see app. A.1.3)

$$\varepsilon_{vwl}\varepsilon_{lA}\varepsilon_{As} = \varepsilon_{vz}\varepsilon_{zs}. \tag{2.13}$$

As in the planner's trade-off, safety has a positive as well as a negative effect here. The negative effect on the left-hand side comes through the reduction in labour demand by the firm as a result of the cost associated with a higher level of safety: A one-percent increase of safety decreases TFP by ε_{As} percent and the labour demand by $\varepsilon_{lA}\varepsilon_{As}$ percent. Multiplying this with ε_{vwl} gives the percentage reduction in utility. The positive effect on the right-hand side is the direct effect of improved health on utility: A one-percent increase in the safety level increases health by ε_{zs} percent which multiplied by ε_{vz} gives the percentage increase in utility.

The differences between the union's optimal s^v from (2.13) and the planner's s^U from (2.8) stem from three sources: First, the union might value health differently than the central planner, i.e. $v(\cdot)$ might differ from $U(\cdot)$. In fact, the union might value health more (i.e. ε_{vz} might be greater than ε_{Uz}) since all workers are affected by workplace conditions while not all consumers are, as some consumers might live on capital income only. Second, the union cares about labour income wl only and not about total consumption C. In other words, capital income of capital owners is not taken into account. Third, maybe most surprisingly, firm-level unions without fixed membership do not take into account the positive effect of an increased level of health on the labour supply and thereby on output, the $\varepsilon_{UY}\varepsilon_{YL}\varepsilon_{zs}$ term in (2.8).

- The trade union confederation

The union confederation has the same objectives as the firm-level union even though it represents, not only the workers from a particular firm, but the whole labour force. Consequently, employment in the union confederation's objective function (2.5) is economy-wide labour supply $L = z\left(s^V\right)N$ and the wage rate from (2.11) is the general equilibrium wage level, $w = w\left(A\left(s^V\right), z\left(s^V\right)N\right)$. The safety level set by the confederation is denoted by s^V. The optimality condition is (see app. A.1.4), using (2.9) again,

$$\varepsilon_{VwL}\varepsilon_{wA}\varepsilon_{As} = \left[\varepsilon_{VwL}\left[1-\varepsilon_{wL}\right] + \varepsilon_{Vz}\right]\varepsilon_{zs}, \tag{2.14}$$

The optimality condition (2.14) again balances the positive and negative effects of a higher safety level. In contrast to the firm-level union, however, the union confederation does take the positive effect of an increased level of health on the labour supply into account , the $\varepsilon_{VwL}\left[1-\varepsilon_{wL}\right]\varepsilon_{zs}$ term. In fact, condition (2.14) has more in common with the welfare-maximizing condition in (2.8) than with (2.13). Comparing (2.8) and (2.14) makes it clear that health per se has a similar impact on both conditions, the terms $\varepsilon_{Uz}\varepsilon_{zs}$ and $\varepsilon_{Vz}\varepsilon_{zs}$. However, the main difference resides in the fact that the union confederation is only interested in the workers' income, wL, while the central planner considers the whole income, that is, the income of workers and of capital holders: $Y = wL + rK$.

2.5.2 An example

While intuitive, the first-order conditions of the planner, the unions or capital owners might not be satisfied. The positive effect of improved health could always be stronger than the negative effect of a lower TFP - or vice versa. The conditions also reveal little about the central determinants of health and safety levels. We therefore now look at a specific example in which a unique optimum can be easily identified and the conflict of interest in our economy can be studied.

- Functional forms

Assume a CES form for utility functions with arguments income and health. The household utility function in (2.2) and the firm-level union's objective function in (2.4) are thus assumed to take the forms

$$u = \left\{\mu c^{\lambda} + \left[1-\mu\right]z\left(s\right)^{\lambda}\right\}^{1/\lambda}, \tag{2.15}$$

$$v = \left\{ \gamma \left[wl \right]^{\lambda} + \left[1 - \gamma \right] z\left(s \right)^{\lambda} \right\}^{1/\lambda}, \tag{2.16}$$

where $0 < \mu, \gamma < 1$ and $\lambda < 1$. The confederation's utility in (2.5) and our example for the central planner's objective (2.7) are

$$V = \left\{ \gamma \left[wz\left(s \right) N \right]^{\lambda} + \left[1 - \gamma \right] z\left(s \right)^{\lambda} \right\}^{1/\lambda}, \tag{2.17}$$

$$U = \left\{ \mu Y\left(s \right)^{\lambda} + \left[1 - \mu \right] z\left(s \right)^{\lambda} \right\}^{1/\lambda}. \tag{2.18}$$

Let there be a CD production function at the firm level and therefore also on aggregate with $0 < \alpha < 1$,

$$y = A\left(s \right) k^{\alpha} l^{1-\alpha}, \tag{2.19}$$

$$Y = A\left(s \right) K^{\alpha} \left[z\left(s \right) N \right]^{1-\alpha}. \tag{2.20}$$

Health is captured in all utility functions by $z\left(s \right)$ with a weight of μ for the households and the central planner and a corresponding weight γ for unions. Unions might value health differently than "normal" households as all union members are subject to health effects from working while households also include capital owners who are not exposed to health hazards. Likewise, income at the household or planner level is all income and can therefore be expressed by individual consumption c or aggregate output Y. Income taken into account by unions is labour income only, i.e. wl or wL. In all cases, the elasticity of substitution between income and health is given by $1/\left(1 - \lambda\right)$. For $\lambda \to 0$, the CES functions (2.15) to (2.18) become CD functions, e.g. $u = c^{\mu} z\left(s \right)^{1-\mu}$ and $v = \left[wl \right]^{\gamma} z\left(s \right)^{1-\gamma}$ for (2.15) and (2.16).

Finally, let us choose functional forms for TFP and the share of time being healthy as related to OHS which have the properties discussed after (2.1) and (2.3),

$$A\left(s \right) = be^{-\phi s}, \qquad z\left(s \right) = 1 - \bar{q} e^{-\chi s}, \tag{2.21}$$

where b, ϕ and χ are positive constants. When s is very low, TFP is close to its maximum b and the share of healthy hours is close to its minimum $1 - \bar{q}$. Restricting $\bar{q}$ to take values between zero and one, zero safety measures still imply that workers are on average healthy during $1 - \bar{q}$ percent of the time. The higher s is, the closer TFP is to zero and the higher the average health $z\left(s \right)$ is.

- Optimal safety levels

The existence of optimal safety levels follows from computing first-order conditions and checking the sign of the first derivative to the left and right of the optimum in general equilibrium. A general equilibrium perspective has been taken for the maximization procedure by economy-wide institutions (the planner and the nation-wide union). Firm-level unions calculate their optimal safety level based on the firm's labour demand function. We take these optimality conditions and replace firm variables (like the capital stock k) by aggregate variables adopting the standard symmetric equilibrium view with many identical unions.

Table 2.1 presents first-order conditions for CES utility functions (2.15) to (2.18) and corresponding CD results for $\lambda \to 0$, i.e. the safety levels for the welfare-maximizing and the output-maximizing planner and for both types of unions (see app. A.2.4).

The safety level s^Y in (b) chosen by a planner who maximizes output only (i.e. $\mu = 1$ in (2.18)) is positive if the term in squared brackets is larger than one, $(1 + (1 - \alpha)\, \chi/\phi)\, \bar{q} > 1$. Given that $\bar{q}$ is the share of time spent sick, this expression is larger than one only for a sufficiently small α or ϕ or a large χ. A small α implies a high output elasticity of labour. A planner will therefore provide more safety when this has a stronger positive effect on output. When ϕ is small, the cost of safety on TFP by (2.21) is not so strong and a planner will also provide more safety measures. Similarly with χ : More safety measures, again by (2.21), increases health levels and labour supply strongly and the planner is induced to provide more safety. Let us assume that parameters are such that the planner indeed chooses a positive safety level s^Y.

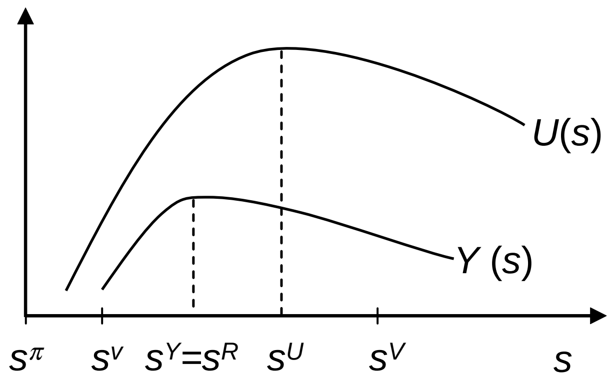
Table 2.1: Optimal occupational health and safety levels for (2.19) to (2.21)

	CES utilities (2.15) to (2.18)	**CD utilities** (2.15) to (2.18) for $\lambda \to 0$	
welfare-planner s^U	$\frac{\ln\left[\left(1+\left[\frac{\varepsilon_{Uz}(s^U)}{\varepsilon_{UY}(s^U)}+1-\alpha\right]\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	$\frac{\ln\left[\left(1+\left[\frac{1-\mu}{\mu}+1-\alpha\right]\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	(a)
output-planner s^Y	$\frac{\ln\left[\left(1+(1-\alpha)\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	identical to CES	(b)
firm-level union s^v	$\frac{\ln\left[\left(1+\frac{\varepsilon_{vz}(s^v)}{\varepsilon_{vwl}(s^v)}\alpha\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	$\frac{\ln\left[\left(1+\frac{1-\gamma}{\gamma}\alpha\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	(c)
confederation s^V	$\frac{\ln\left[\left(1+\left(\frac{\varepsilon_{Vz}(s^V)}{\varepsilon_{VwL}(s^V)}+1-\alpha\right)\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	$\frac{\ln\left[\left(1+\left(\frac{1-\gamma}{\gamma}+1-\alpha\right)\frac{\chi}{\phi}\right)\bar{q}\right]}{\chi}$	(d)

When looking at the signs of the first and second derivatives, one finds that s^Y is indeed an optimum and one obtains an "inverted U" shape for $Y(s)$ from (2.20) as illustrated in fig. 2-1. To the right of s^Y, the positive effect of an increase in the safety level on health and thereby labour supply overcompensates the negative effect of lower TFP. This reverses to the left of s^Y.

The other expressions in table 2.1 are implicit for the CES utility functions, as the elasticities $\varepsilon(\cdot)$ are functions of the safety levels. We will return to these forms further below. For the CD case, we also obtain straightforward solutions which can be given similar interpretations with regard to the output-maximizing safety level. The additional factor in (a), (c) and (d) are the preference parameters μ and γ. When health is valued strongly, i.e. μ and γ are low, the welfare, firm-level union or confederation safety levels, as expected, go up. Again, looking at the signs of the CD first and second derivatives shows that the optimal safety levels are indeed maxima.

Figure 2-1: Output and welfare as a function of occupational health and safety s



- Conflict of interests?

Who wants what in our economy? Given the richness of channels visible in the CD-results of table 2.1, we make a weak assumption concerning parameters which allows us to focus on the most realistic conflicts of interest: $\alpha < \gamma < \mu$. The output elasticity of capital, α, is around 1/3. When comparing this to γ, the value attached by unions to labour income in (2.16) and (2.17), our assumption says that unions, even though they are health-oriented, attach a weight of at least 1/3 to labour income. The second part of the assumption says that unions value health more than society as a whole, $\gamma < \mu$. This also appears plausible as members of unions are all subject to health risks while society also consists of capital owners who are not.

The planner, the unions and the capital owners all potentially desire different safety levels. The planner can appear either in its welfare or in its output-maximizing guise, unions and capital owners are both represented at the firm and the nation-wide level. With our assumption and

CD results from table 2.1, we find (see app. A.3.2)

$$s^{\pi} < s^{v} < s^{R} = s^{Y} < s^{U} < s^{V}. \tag{2.22}$$

The output-maximizing planner and the capital owners agree on the safety level, $s^R = s^Y$. What maximizes output, maximizes capital income rK, clearly a property of the CD structure of output in (2.20). The welfare-maximizing planner wants a higher safety level than the output planner, $s^Y < s^U$, see fn. 9.

Nation-wide unions desire a higher OHS level than the welfare planner due to $\gamma < \mu$. If society and nation-wide unions had identical preferences ($\gamma = \mu$), unions could replace the central planner. They would internalize the production externality and would set the welfare-maximizing safety level.

When looking at capital and labour representatives at the firm level, we know already from the discussion after (2.11) that firms want the lowest possible safety level s^{π}. Concerning unions, we find a surprising result: Firm-level unions want a lower safety level s^v than capital owners or a central planner who is purely interested in output maximization. The reason is that the central planner (and the capital owners) know about (and internalize) the benefits of improved health levels for labour supply. The firm-level union sees positive effects from higher OHS standards only in its pure health effect and neglects labour supply effects (in fact, it looks at labour l in its objective function as the labour demand by firms which falls as TFP falls as a result of higher safety levels).[14]

Summarizing, the nation-wide union, given its "exaggerated" emphasis on health is in conflict with society as a whole which in turn wants higher OHS standards than output-maximizers and capital owners. The lowest safety providers are firm-owners and firm-level unions.[15] Comparing union output and welfare with a laissez-faire economy is straightforward when using fig. 2-1. Unions are welfare or output increasing if the safety level that they set is to the left of s^Y and s^U, respectively. If they "overdo things", i.e. if the union safety level is too far to the right of s^Y or s^U, they would still be beneficial to the economy if the negative effect on TFP is not too strong, i.e. if the decrease of output and welfare to the right of their maxima is modest. For illustration purposes, the ranking in (2.22) is also plotted in fig. 2-1.

[14] Departing from our parameter assumption would imply that a firm-level union sets a higher safety level than a central output-planner if it only values health enough. App. A.3.2 shows that $s^v \lesseqgtr s^Y \Leftrightarrow \alpha \lesseqgtr \gamma$.

[15] Again, departing from our assumption on parameters, one can show that for $\gamma = \alpha\mu$ the firm-level union would set the same safety level as a planner $s^v = s^U$ (see app. A.3.2).

2.5.3 OHS and development

Empirical analyses suggest a negative correlation between the development level of a country and the risk of injury while working (Hall and Leeson, 2007, Flanagan, 2006, pp. 44-7). Should this give rise to policy concerns or is this a feature of an efficient development process?

Using the implicit-function theorem on CES safety levels as presented in table 2.1 shows that the reaction depends on the elasticity of substitution between income ($w^i l^i$ for the firm-level union, $w^i z^i N^i$ for the union confederation and Y^i for the planner) and health z^i (see app. A.4),

$$\left.\begin{array}{c}\text{bad substitutes}\\ \text{Cobb-Douglas (CD)}\\ \text{good substitutes}\end{array}\right\} \Leftrightarrow \lambda \lesseqgtr 0 \Rightarrow \frac{ds^{j,i}}{dK}\left\{\begin{array}{l}>0\\ =0\\ =?\end{array}\right. , \quad s^{j,i} \in \left\{s^{v,i}, s^{V,i}, s^{U,i}\right\}. \tag{2.23}$$

Both the planner and the two types of unions would set a higher safety level if the elasticity of substitution between health and income is low. This can be understood by referring to the income and substitution effect. There is an income effect due to more capital which increases demand for health $z\left(s^i\right)$ and consumption, the two arguments in the planner's utility function in (2.7). The price of health relative to consumption, however, rises the more capital there is and households tend to substitute health by income.

In the CD case these effects cancel. Safety levels do not change in the course of the development of a country. This would be the "universal work standard" case advocated by some who postulate that all countries in the world, irrespective of their level of development, should have the same OHS standards. When substitution is easy, it is not clear which effect is stronger. In this case, health standards could even decrease when a country becomes richer. The substitution effect would dominate the income effect.

The case that seems to be empirically more relevant is the one in which work standards are higher, the higher the development level of a country is (Hall and Leeson, 2007, Flanagan, 2006, pp. 44-7). This is the bad substitution case ($\lambda < 0$) in our model. When a society becomes richer, it can afford higher health standards and as income is a bad substitute for health, OHS standards go up accepting that this reduces TFP and therefore dampens the increase in income. Our view that the positive link between development and OHS standards is also due to unions is also shared by Kahn (1990, p. 481) who writes that "union workers implicitly trade off wage and benefits growth for occupational safety improvements".

Note that this empirical finding also points to the fact that real-world economies generally do not have a laissez-faire safety level of s^{π} as introduced after (2.11). In a laissez-faire economy, more capital does not imply better OHS standards. Only if unions (or a benevolent central planner or related institutions) are present, can the safety level increase in the course of economic development.

2.6 Conclusion

The starting point of this chapter was the belief that institutions like trade unions, which have been around for more than a century and are active in almost all countries in the world, are not just detrimental to economic production and welfare of a society. Studying activities of workers' associations and trade unions beyond wage negotiation has shown that trade unions play a major role in providing workplace safety - at least in providing information about the necessity of measures that assure occupational health and safety (OHS). Trade unions did perform this role historically in what are now OECD countries and do play such a role today in certain industrializing economies.

Can these OHS activities of unions assign unions an output and welfare increasing role? Our analysis has shown that output and welfare effects of unions depend on union objectives and, more importantly, on the degree of centralization in an economy. Firm-level unions set lower OHS standards than economy-wide unions as the former neglect the positive labour supply effect of higher OHS. Firm-level unions are just as short-sighted (i.e. focused on this one firm) as firms and treat employment as the outcome of labour demand decisions by the firm. They provide OHS only as they value the health of their members per se. Economy-wide unions fully internalize the positive labour supply effect due to more OHS and therefore set higher safety standards. In fact, ruling out distributional effects from variations in the size of the labour force (i.e. assuming a Cobb-Douglas technology), economy-wide unions which attach the same importance to health as society as a whole set the social welfare-maximizing OHS standards. Even with a firm-level union, output and welfare increases compared to a laissez-faire economy.

Can other institutions play a similar role to unions? We have seen that capital owners - as opposed to individual atomistic firms - would also internalize economy-wide labour supply effects and value the health of workers. Capital owners trying to maximize their revenue would increase overall output and welfare of an economy as compared to a laissez-faire economy but never up to the social welfare-maximizing point. The incentives for capital owners to form a coalition and internalize the negative health externality, however, are much lower than for workers. Capital owners "do not feel health hazards". It is only the workers who are directly confronted with risk at work. Hence, workers' associations are the most probable institution to initially play this output and welfare increasing role. After some time, when general awareness in society about OHS standards or particular health issues has grown, the role of trade unions can be taken over by society as a whole, i.e. by some voting process through a government. This might be the reason why in the US, UK, Germany and many other OECD countries, governmental agencies take care of OHS standards nowadays and provide various types of work and health related insurances - and partly even make them compulsory.

The chapter has various shortcomings which can be overcome in future work. Can unions play a welfare-increasing role in industrialized countries today where OHS standards are set by government agencies? One would have to start with an analysis where some firms or sectors in the North are unionized while others are not. A partial unionisation setup would also be useful to understand the effects of unions in the South better. Any increasing role would come gradually and unions would not become monopoly unions instantaneously. Second, the assumption of ignorance on the side of workers and perfect information of unions can be replaced by a Bayesian learning approach. One can expect that the relative degree of risk-aversion of workers (with respect to labour income relative to health effects) will determine whether "optimistic" workers (their prior predicts a higher expected share of time being healthy than a certain job actually implies) accept higher or lower wages than the perfect information compensating differential wage. One can then also precisely analyse the incentives for workers to join a union (thereby also reflecting the fact that no real-world economy is 100% unionized) and understand how joint learning increases welfare. Third, what happens if unions are allowed to set or negotiate wages? Is the traditional labour rationing distortion always overcompensated by the positive safety setting as portrayed here? All these extensions would make it possible to better understand the extent to which joint action and cooperative behaviour - as opposed to an individualistic view of society - is important for forming modern humane societies.

Chapter 3

Globalization and labour standards[1]

3.1 Introduction

The international trade literature has mainly focused on the impact of globalization on wages, employment, and, more recently, on cultural issues. This literature has provided very important insights but has largely ignored how globalization affects labour standards such as occupational health and safety (OHS). This chapter fills this gap by introducing a theoretical model that allows to study the effects of globalization on OHS.

The framework is an extended version of the basic model from Chapter 2 to a two-country world consisting of "the North" and "the South". These two countries are exactly the same except that the North is capital rich and has trade unions that set high OHS standards. The South is capital poor and OHS standards are low because there are no trade unions there. The model studies the welfare effects if these two countries open up their borders to international trade in the final homogenous good and capital.

It turns out that capital flows from North to South until its marginal productivity is equal in both regions. As in traditional factor movement models, the impact of globalization due to a better capital allocation (the capital-allocation effect) is welfare increasing for both regions. However, since the capital stock in the North is reduced, workers' wage income decreases, and unions react by reducing their demands on high OHS standards (the OHS effect). This has a negative effect on welfare in the North.

The model then studies the welfare impact if trade unions are also introduced in the South. The first consequence is that southern unions increase safety levels in the South. This improves

[1] This chapter is part of a joint paper with Klaus Wälde. The entire paper appeared as Donado and Wälde (2010a). The background to the text shown here, the equations and the appendix were all provided, derived and computed by Alejandro Donado.

southern welfare as in the autarky model from Chapter 2 but it also implies an increase in the marginal productivity of capital in the South. This leads to even more capital flowing from North to South. The impact of globalization due to better capital allocation is also unambiguously positive in both regions. In the North, however, unions set even lower OHS standards, further reducing northern welfare. In the South, the higher capital stock implies that unions increase southern OHS standards, magnifying the positive impact of globalization on southern welfare.

In more general terms, the model finds that bringing down the trade and FDI barriers has a clear positive allocative welfare impact, as in traditional trade models. The impact on labour conditions, however, is positive only for countries that can attract capital inflows and, more importantly, for countries that have an institution, like trade unions, that can "extract" better working conditions from this additional capital. The model suggests that globalization is a win-win situation for the South. In the North, globalization leads to a welfare improvement only if the capital-allocation effect is bigger than the negative OHS effect.

As mentioned before, there is no theoretical study that investigates the impact of globalization on OHS. There is however a growing literature on the impact of globalization on child labour (see Edmonds and Pavcnik 2006, Levine and Rothman 2006, Neumayer and Soysa 2005, Dinopoulos and Zhao 2007, and Davies and Voy 2009). The main result from this literature is that international trade seems to reduce the incidence of child labour. This result is similar to the predictions of the model introduced in this chapter since it provides evidence that globalization improves labour conditions in poor countries (the South).

Other studies have investigated the effects of unions on wages and employment in an international framework. Notable examples include Mezzetti and Dinopoulos (1991), Brander and Spencer (1988), Naylor (1999), Zhao (1995, 1998), Skaksen and Sørensen (2001), Aloi et al. (2009), Boulhol (2009) and Eckel and Egger (2009). These studies, however, do not address OHS issues.

Finally, two empirical studies suggest that there is an important positive correlation between better safety measures, or health in general, and FDI inflows. Flanagan (2006) finds that investment shares are lower in countries with relatively high fatal job accidents rates, while Alsan et al. (2006) find empirical evidence that an improvement in a population's health increases gross FDI inflows to low- and middle-income countries. These two papers provide support for the model's prediction that capital flows to the South if OHS standards are improved there.

The rest of the chapter is organized as follows. Section 3.2 introduces the two-country model. Section 3.3 studies the effects of globalization if unions are only present in the North, while section 3.4 studies the effects if unions are also present in the South. Section 3.5 concludes.

3.2 The two-country model

3.2.1 Basic structure

Our model economy generalizes the model in Chapter 2 to a two-country world consisting of the capital-rich North and the South. Both countries produce a homogenous aggregate good Y^i, where i denotes either North or South. A typical firm produces the quantity y^i by employing capital k^i and labour l^i, the latter of which is measured in working hours. All firms use the same technology with TFP $A\left(s^i\right)$,

$$y^i = A\left(s^i\right) f\left(k^i, l^i\right), \tag{3.1}$$

where capital and labour inputs have the usual neoclassical effects on output. We assume that all firms can hire from a spot market. There are no hiring or firing costs and it does not take any time to find a worker. Factors are paid their value marginal product.

The central focus of this chapter is occupational health and safety (OHS) in a global world. This aspect is reflected in the production process via the TFP component $A\left(s^i\right)$. A job is safe(r) if a worker is (more) certain to return home in good health after 8 (or more) hours of work. We capture safer jobs by a higher $s^i > 0$.

Safe workplaces are clearly in the interest of the worker, and in many cases, OHS is also a central concern for employers. More often, however, there is a fundamental conflict of interest since OHS measures are costly. For modelling purposes, we go to the extreme and exclude firms from any benefits resulting from higher safety. We capture safety costs by letting OHS measures reduce TFP, $A_{s^i} < 0$, where throughout the chapter subscripts denote partial derivatives. Given the spot market assumption, a sick worker would simply be replaced by a new healthy worker.

Utility of workers increases in consumption c^i and health $z\left(s^i\right)$ but with a decreasing slope. We assume that better safety measures s^i improve health, $z_{s^i} > 0$. The utility function is given by

$$u^i = u\left(c^i, z\left(s^i\right)\right). \tag{3.2}$$

On the aggregate level, consumption equals output $C^i = Y^i$ and labour demand L^i equals labour supply,

$$L^i = z\left(s^i\right) N^i, \tag{3.3}$$

where N^i denote potential employment (also measured in hours and assumed to be fixed) multiplied by the share $z\left(s^i\right)$ of time workers are healthy and can actually work. More safety, implying more health, implies higher labour supply in each country.

We finally turn to trade unions. Trade unions can operate at the country, sectorial or firm level. They played a very important historical role in setting OHS standards as discussed in detail in Chapter 2. We assume here that unions operate at the firm level only. Due to the spot market assumption, there is no attachment of workers to the firm. Hence, membership of firm-level unions is just as volatile as employment at the firm. As a consequence, the union only cares about the overall well-being of the l^i workers in this particular firm. Given historical examples of union behaviour in what are now OECD countries and preferences of households in (3.2), unions not only care about labour income $w^i l^i$, but they also care about a worker's health $z\left(s^i\right)$. The union's utility function increases in both arguments and reads

$$v^i = v\left(w^i l^i, z\left(s^i\right)\right). \tag{3.4}$$

Labour income of union members depends on the market wage w^i and on labour demand l^i as chosen by the firm. Depending on the importance attached to each of these two objectives, the union might be called income-oriented or health-oriented.

3.2.2 Occupational health and safety

Nowadays, health and safety standards in OECD countries are by and large regulated by government agencies. Historically speaking, however, worker movements or trade unions played a very important role. This is still the case for developing countries today where governmental institutions are not as strong as in OECD countries. There is also evidence that unions in developed countries still play an important role when it comes to the *implementation* of statutory OHS standards. Weil (1991, 1992) shows that OHS standards are better enforced in the presence of unionized workers. In the case of new technologies or new evidence of health implications, physical working conditions are one important issue which trade unions and management still negotiate over today (Millward et al., 1992, pp. 249-254). Due to the historical and current importance of unions for OHS in OECD countries, in the following we will talk about OHS setting as an activity which maximizes the utility function (3.4) of the union. One could also think of (3.4) as the objective function of a government agency which took over unions' role of taking care of OHS setting.[2]

We now ask what the OHS standard in the North would be if standards are set by (i) a

[2] The analogy would not work entirely if government agencies take an economy-wide approach to OHS in contrast to our firm-level unions. If the government agency is structured according to industries as safety standards are very industry-specific, however, then the analogy would work. It would clearly be of interest to look at OHS setting also from a political-economy point of view.

firm-level union/government agency and, as reference points, (ii) by a central planner focusing on output and (iii) by a central planner focusing on welfare. For later purposes, we (iv) also calculate the interest-rate maximising OHS level. The respective objective functions and the optimality conditions are summarized in tab. 3.1. For a derivation of optimality conditions, see app. B.1.

Table 3.1: Optimal occupational health and safety levels in the North

agent	objective function	
consumption planner: s^C	$C(s) = Y(A(s), K - \Delta(s), z(s)N) + r^*(s)\Delta(s)$	(OFa)
welfare planner: s^U	$U(s) = U(C(s), z(s))$	(OFb)
firm-level union: s^v	$v(s) = v(wl(s), z(s))$	(OFc)
capital owners: s^R	$r[K - \Delta(s)] + r^*(s)\Delta(s)$	(OFd)
agent	**optimality condition**	
consumption planner: s^C	$\left[\varepsilon_{YA} + \varepsilon_{\tilde{r}A}\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{As} = \left[\varepsilon_{YL} + \varepsilon_{\tilde{r}L}\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{zs}$	(OCa)
welfare planner: s^U	$\varepsilon_{UC}\left[\varepsilon_{YA} + \varepsilon_{\tilde{r}A}\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{As} = \left[\varepsilon_{UC}\varepsilon_{YL} + \varepsilon_{Uz} + [\varepsilon_{UC}\varepsilon_{\tilde{r}L} + \varepsilon_{Uz}]\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{zs}$	(OCb)
firm-level union: s^v	$\varepsilon_{vwl}\varepsilon_{lA}\varepsilon_{As} = \varepsilon_{vz}\varepsilon_{zs}$	(OCc)
capital owners: s^R	$\varepsilon_{\tilde{r}A}\varepsilon_{As} = \varepsilon_{\tilde{r}L}\varepsilon_{zs}$	(OCd)

For readability, all elasticities throughout this chapter are defined as positive quantities. Only the OHS elasticity of TFP requires a minus sign in its definition,

$$\varepsilon_{As} \equiv -\frac{\partial A}{\partial s}\frac{s}{A}, \qquad \text{and} \qquad \varepsilon_{xy} \equiv \frac{\partial x}{\partial y}\frac{y}{x} \qquad \text{for all} \quad xy \neq As. \tag{3.5}$$

North-South capital flows are denoted by Δ[3] and the equilibrium interest rate is denoted by $\tilde{r}$.[4]

The optimality condition (OCc) of firm-level unions in tab. 3.1 given the objective (OFc) is identical to the closed-economy findings of Chapter 2 as firm-level unions look at the wage only and take the aggregate capital stock as given. The central planner in a two-country world does however take into account that more or less OHS standards imply more or less capital. In addition to this, income is no longer given by domestic production but by domestic production plus foreign capital income - which is consumption $C(s)$ in (OFa). The welfare planner has structurally the same objective function (OFb) as in the closed economy but needs to take international capital flows into account. The objective function of capital owners in (OFd) adds

[3] Maybe one should not talk about flows in a static model. Strictly speaking, Δ is the stock of capital installed in the South but owned by the North.

[4] When we want to stress that a variable or parameter belongs to the South, we denote it by an asterisk "*". For the North, we use nothing, as in tab. 3.1, which refers to the North only. In this sense, in section 3.2.1, i stands for either nothing or this asterisk.

domestic capital income to foreign capital income.

The left-hand sides (LHS) of the optimality conditions in (OC) show the costs and the right-hand sides (RHS) the benefits of an increase in the safety level from each agent's perspective. Let us first focus on conditions (OCa) to (OCc). In all these three conditions the costs originate from a reduction of TFP caused by an increase in the safety level, but the variables affected are different. In fact, a lower TFP implies in condition (OCa) a lower consumption C (due to a reduction in both Y and $\tilde{r}$), in condition (OCb) a lower welfare U (due to a reduction in consumption), and in condition (OCc) a lower union's utility v (due to a reduction in the firms' labour demand l). For example, the LHS of condition (OCb) has a straightforward interpretation: A one-percent increase in the safety level reduces the TFP and thereby output by $\varepsilon_{YA}\varepsilon_{As}$ percent and the world interest rate by $\varepsilon_{\tilde{r}A}\varepsilon_{As}$ percent. Multiplying these terms with the consumption elasticity of welfare, ε_{UC}, yields the percentage reduction in welfare due to lower consumption. The second term is weighted with $\tilde{r}\Delta/Y$ implying that the negative impact on consumption via a reduction in capital income is greater, the more important capital income $\tilde{r}\Delta$ is relative to output Y.

The benefits on the RHS of all three conditions originate from an improvement in the health level z of the labour force. A higher health level implies in condition (a) a higher consumption C (due to an increase in both Y and $\tilde{r}$), in condition (OCb) a higher welfare U (due to an increase in consumption), and in condition (OCc) a higher union's utility v (since better health has a direct positive impact on the union's utility). Again, the RHS of (OCb) has a simple interpretation: A one-percent increase in the safety level increases the health level of the labour force, raising output by $\varepsilon_{YL}\varepsilon_{zs}$ percent and the world interest rate by $\varepsilon_{\tilde{r}L}\varepsilon_{zs}$ percent. Multiplying these terms with the consumption elasticity of welfare, ε_{UC}, yields the percentage increase in welfare caused by a higher consumption. Moreover, terms two and four, $\varepsilon_{Uz}\varepsilon_{zs}$ and $\varepsilon_{Uz}\varepsilon_{zs}\tilde{r}\Delta/Y$, on the RHS of (OCb) show that better health also has a direct positive impact on welfare.

There are three interesting aspects to these optimality conditions that should be highlighted. First, if the planner focused only on consumption maximization (that is, if $\varepsilon_{Uz} = 0$), the optimality condition (OCb) would be reduced to (OCa). Second, the optimality conditions (OCa) and (OCb) are equal to their counterparts in the closed economy if we set $\Delta = 0$ (see Chapter 2). Finally, even if condition (OCc) is equal to its closed-economy counterpart, the resulting safety levels are different. The reason is that the safety levels are dependent on aggregate wages and these wages depend positively on the country's capital stock. As a consequence, if capital leaves the country, wages are lower, and trade unions demand lower safety levels.

To conclude, the trade-off for capital owners in (OCd) is easy to understand. The LHS shows the losses due to lower TFP, the RHS shows the gains in the North due to more healthy workers. Both losses and gains affect capital owners through the equilibrium interest rate $\tilde{r}$.

3.2.3 Equilibrium

The North can carry out FDI and trade the final homogeneous good with the South. In autarky, the South has a lower capital stock per capita and safety levels are lower as well. For simplicity and without losing any insight, we consider the southern safety level to be exogenous. As the law of one price holds without barriers to trade, the single determinant for capital flows are international differences in the marginal product of capital. Using the aggregate version of technology (3.1) and the equilibrium on the labour market (3.3), the marginal product of capital in the North is given by

$$r = r(s, K - \Delta) = A(s) \frac{\partial f(K - \Delta, z(s) N)}{\partial (K - \Delta)}, \tag{3.6}$$

where K is the endowment of the capital stock in the North and Δ are North-South capital flows. As this expression shows, OHS standards s have an ambiguous effect on the interest rate: If the safety level is too low, capital owners are in favour of more safety since they see the overall positive effect of healthier workers. If the safety level s is too high, the TFP-reducing effect is stronger than the labour-supply effect.

Equilibrium on the world capital market requires equality of the factor rewards for capital,

$$r(s, K - \Delta) = r(s^*, K^* + \Delta), \tag{3.7}$$

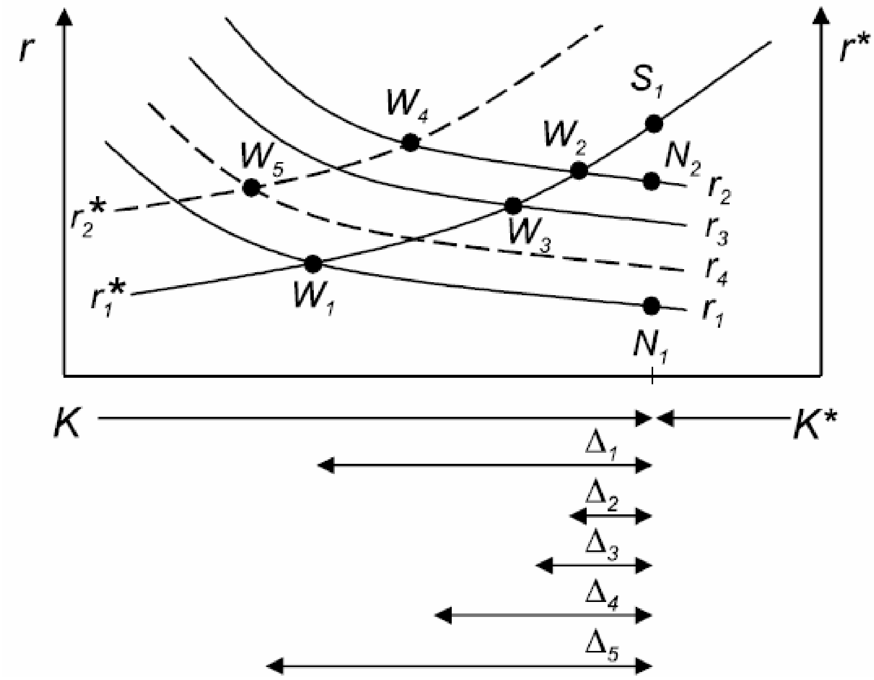
where an asterisk denotes southern variables. This equation determines Δ, given the exogenous autarky endowments K and K^*, an exogenous southern safety level s^* and the endogenous safety level s in the North, i.e. $\Delta = \Delta(s)$. The latter continues to be determined by unions in the North as described by (OCc). An equilibrium in our setup is therefore given by (3.7) and (OCc). These two equations determine two endogenous variables: capital flows Δ from North to South and safety levels s in the North.[5]

The equilibrium on capital markets is plotted in fig. 3-1. The horizontal axis shows the northern capital stock from the left and the southern from the right such that the total length

[5] Keeping s^* exogenous simplifies the exposition. It becomes endogenous if we assume that an equation in analogy to (OCc) would hold for the South as well. We would then have a setup where unions do not act strategically. One could also study North-South games to explain why international union cooperation so often failed in the past (see p. 42 for references).

of the horizontal axis reflects world endowment with capital, $K + K^*$. The vertical axis on the left shows the northern interest rate, the one on the right the interest rate in the South. Capital demand curves plot loci which give the interest rate as a function of capital used in the North and South, respectively.

Figure 3-1: Autarky equilibria N_i and S_i and world equilibria W_i with free capital flows



3.3 OHS under trade and capital flows

Let us now analyse the effects of "globalization", i.e. international capital flows, on safety standards and thereby on output and welfare.

3.3.1 Capital flows in a two-country world

Thinking of a scenario where countries are in autarky and then open up for capital flows, let us assume first that countries in autarky differ only in their per-capita capital stock. There are no union activities and safety levels are identical and low. When the initial capital endowment before capital flows is given as drawn in fig. 3-1, factor rewards in the South at S_1 are higher than in the North at N_1. With free capital flows, the new world-equilibrium point is at W_1 where capital flows from the North to the South of a total volume of Δ_1 imply an equalization of returns to capital.

Are capital flows from the North to the South a realistic description of reality? It is well-known that the US as one of the richest countries in the world is one of the biggest recipient of foreign investments. When capital flows in "all" countries in the world are analysed, capital flows from the North to the South from the 70s to the mid 80s, reverses subsequently and flows South to North from the end of the 90s (Prasad et al., 2006, chart 2). If the focus is on FDI, however, capital always flows from North to South (chart 4). If the world excluding the US is analysed, capital also flows from North to South (chart 3). Lane and Milesi-Ferretti (2007, fig. 9) make a similar point: Net foreign assets (i.e. accumulated flows) are positive for industrialized countries and negative for the US and emerging and developing countries. Capital flows from North to South are therefore a realistic view of the world if the focus is on FDI (which comes the closest to our variable Δ in this long-run static equilibrium) or if the focus is on industrialized countries other than the US.[6]

Second, if we introduce trade unions in the North, the autarky safety level is higher than without unions. Let us assume this OHS level does not respond to changes in the capital stock. Section 2.5.3 has shown that this holds for the firm-level union if the union's objective function (3.4) has a Cobb-Douglas structure. As long as this OHS level is not beyond the capital-return maximizing point (i.e. as long as $s^v < s^R$ from (OC in tab. 3.1)), the capital demand function moves up from r_1 to r_2. As has been discussed after the expression for the marginal productivity of capital in (3.6), capital owners are actually in favour of higher safety levels as long as this has a positive effect on capital rewards. Starting with the same initial capital distribution, the starting points are now S_1 and N_2 and the new world-equilibrium point is W_2. Capital flows from the North to the South are now lower and amount to Δ_2 only. Higher (but not too high) safety levels reduce capital outflows from the North.

When we return to the realistic situation where health and income are bad substitutes (see sect. 2.5.3), safety standards fall after capital outflows. Starting from N_2 and S_1 as before, capital outflows will lead to a "temporary" equilibrium at W_2. Falling OHS levels reduce the northern capital demand function to r_3 and the final equilibrium point is W_3. Capital outflows are larger due to the fall in OHS levels in the North but still lower than in a situation without any northern OHS standards. Generally speaking, this contradicts the often stated view that capital flows to where standards are lower. If standards are so low that marginal productivity of capital suffers, capital will stay in the North.

[6] If one focuses on gross flows, it is even more apparent that North-South flows are very relevant. Capital outflows from the US from 1960 to 2007 are on average 3.8 times higher than (absolute) net flows (BEA, 2008).

3.3.2 Capital flows and welfare

Let us now turn to the welfare effects of international capital flows. Welfare in both countries in (OFb) is a function of consumption and health. In the North, endogenous OHS standards s and therefore health are a function of capital flows, $z(\cdot) = z(s(K - \Delta))$. In the South, health $z^*(s^*)$ is exogenous due to exogenous safety levels s^*. Consumption in the North is given by domestic production plus capital income from abroad, $Y + r^*\Delta$, while in the South it is domestic production minus capital income paid to foreign capital owners in the North, $Y^* - r^*\Delta$. Making the dependence of consumption on capital flows Δ explicit, we obtain an expression related to (OFa),

$$C = Y\left(A\left(s\left(K-\Delta\right)\right), K-\Delta, z\left(s\left(K-\Delta\right)\right)N\right) + r^*\left(K^*+\Delta\right)\Delta, \tag{3.8}$$

$$C^* = Y^*\left(A^*\left(s^*\right), K^*+\Delta, z^*\left(s^*\right)N^*\right) - r^*\left(K^*+\Delta\right)\Delta, \tag{3.9}$$

we see that capital flows Δ affect the northern consumption level through TFP, the capital stock, labour supply and the northern interest income. For the South, only the southern capital stock and the interest payments are affected. Computing the welfare effects of capital flows then gives (see app. B.3.1)

$$\frac{dU}{d\Delta} = U_C\left[r^* - r + r^*_\Delta \Delta\right] + U_C Y_s \frac{\partial s}{\partial \Delta} + U_z z_s \frac{\partial s}{\partial \Delta}, \tag{3.10}$$

$$\frac{dU^*}{d\Delta} = -U^*_{C^*} r^*_\Delta \Delta > 0, \tag{3.11}$$

where again subscripts denote partial derivatives: e.g. r^*_Δ is the change in the southern interest rate due to capital inflow into the South.

Capital flows influence northern welfare through the "classic channel", the "efficiency channel" and the "health channel". The first term in (3.10) starting with U_C is the classic channel which says that if the southern interest rate r^* does not react to capital flows from the North (that is, if $r^*_\Delta \Delta = 0$), there are welfare gains as long as the foreign interest rate is larger than the domestic one ($r^* > r$). This is the well-known condition for gains from capital mobility. However, if a sizable amount of capital has already flowed out and the southern interest rate falls when more capital flows (that is, if $r^*_\Delta \Delta < 0$), there might not be gains from additional capital flows. In fact, in a two-country world, welfare-maximizing capital flows should stop before the domestic interest rate equals the foreign one.[7] As the gains from higher capital rewards abroad compensate for the losses from the fall in foreign capital rewards when capital flows just start,

[7] This effect is familiar from the literature on international factor flows in two-country worlds or in the case of *large* open economies. So far, however, we have been unable to find a reference. We are grateful to Juergen Meckl for discussion of this point.

we conclude that, overall, there are gains from international capital flows.

The second term, $U_C Y_s \partial s/\partial\Delta$, can be called the "efficiency channel". If the planner in the North maximized output and set OHS standards equal to s^Y, this term would be zero, $Y_s = Y_A A_s + Y_L z_s N = 0$. The negative TFP effects of safety (the expression $Y_A A_s$) would just be compensated for by the positive labour supply effect $Y_L z_s N$. If, however, OHS standards were below the output-maximizing safety s^Y, that is if $Y_s > 0$, and noting that an outflow of capital reduces the safety level ($\partial s/\partial\Delta < 0$, as discussed after fig. 3-1), a further reduction of s caused by capital outflows would increase inefficiencies in the North and thereby reduce output.

The final term in (3.10) $U_z z_s \partial s/\partial\Delta$ relates more to trade unions and their impact on higher OHS standards. The closer the union-set safety level is to the social welfare-maximizing level s^U, the higher the social welfare is. If the union safety level is lower than s^U, that is, if $U_z > 0$, any reduction in safety levels (due to capital outflows) reduces welfare. Consequently, the welfare effect of reduced OHS standards is negative.

Combining all three channels, capital flows increase northern welfare due to a more efficient factor allocation but reduce welfare since less capital implies lower OHS standards which were already too low before capital flows. This reduction has a negative effect on efficiency and health per se. Welfare gains through capital flows are therefore reduced by negative OHS effects.[8]

For the South, however, the welfare effects are unambiguously positive. For each unit of capital flowing into the country, it pays the local marginal product. Hence, the term $r - r^*$ we see in (3.10) is zero in (3.11). It benefits, however, from the reduction of the domestic interest rate caused by inflows, $r^*_\Delta < 0$. There is no health channel as safety standards are invariant.

3.4 Trade unions go global!

This section is motivated by the general discussion about the desirability of trade unions and their role in a global world. Given competition between the North and the South, can the North afford to have "old-fashioned" institutions like trade unions? Do "modern global times" not require unions to be abolished in order to make a country more "competitive"? Or should governments rather encourage trade union activities in the South as well?

In order to address these questions, we now ask how the results obtained so far are affected if trade unions are also introduced in the South. What are the welfare consequences for the North, the South, and the world economy and how would northern trade unions react to this?

[8] Clearly, if one believes that OHS standards are excessive, i.e. above s^U, capital outflows implying a reduction of safety levels would imply welfare gains caused by capital flows per se and by reduced OHS standards.

3.4.1 International capital flows and OHS

We stipulate that an increased presence of trade unions in the South would increase southern safety levels. If we assume that this new level is still lower than the interest-maximizing southern safety level (that is, if $s^* < s^{R^*}$), an increase in the southern safety level will increase the capital demand curve from r_1^* to r_2^* (see fig. 3-1). Capital owners are better off. Of course the question arises why it takes trade unions to help capital owners to increase their returns from investment. However, the answer is simple: In a society with few economic institutions and no well-functioning financial systems, each capital owner is basically an entrepreneur who owns his own firm. OHS standards imply costs but there are no institutions which would allow capital owners to coordinate their activities and credibly jointly increase safety levels. Firms are caught in a prisoners' dilemma. The need for higher safety levels is more pressing for workers as they are physically affected by negative health effects. Hence, even though each individual firm in the South will be opposed to higher OHS standards, capital owners as a group will gain.

For an invariant safety level in the North (again, the Cobb-Douglas case for union preferences (3.4)), this implies that the equilibrium moves from W_2 to W_4 and the flow of capital to the South increases from Δ_2 to Δ_4. For the empirically most relevant bad-substitution case, capital outflows to the South reduce safety levels in the North. If safety levels were below the interest rate maximizing level s^R, capital demand in the North would be reduced from r_3 to r_4 and the equilibrium would move from W_3 to W_5. Capital outflows from the North would increase from Δ_3 to Δ_5.

At first glance, it might be surprising that introducing trade unions in the South can increase capital inflows to this country. But, if TFP losses are not too large, northern investors simply profit from a healthier labour force in the South. This idea is supported by empirical evidence. For example, Alsan et al. (2006) find that an improvement in a population's health increases gross FDI inflows to low- and middle-income countries. More directly, Flanagan (2006) finds a significant negative correlation between fatal job accident rates and FDI inflows. If trade unions can play a similar role in the South today as they played historically in what are now OECD countries, trade unions can be good for the health and growth of a developing country.

3.4.2 Global unions and welfare

- The North and the South

What are the welfare implications if trade unions in the South increase southern safety levels? Preserving s^* as an exogenous quantity, welfare effects for the North and South are (see app. B.3.2),

$$\frac{dU}{ds^*} = U_C r^*_{s^*} \Delta + U_C Y_s \frac{\partial s}{\partial s^*} + U_z z_s \frac{\partial s}{\partial s^*}, \tag{3.12}$$

$$\frac{dU^*}{ds^*} = -U^*_{C^*} r^*_{s^*} \Delta + U^*_{C^*} Y^*_{s^*} + U^*_{z^*} z^*_{s^*}. \tag{3.13}$$

These conditions look similar to those in (3.10) and (3.11) where the effects of capital flows were analysed. In fact, term one in (3.12) corresponds to the classic channel above. In contrast to above, however, we start from an integrated world economy with $r = r^*$ and capital flows are now induced by changes in southern OHS standards s^*. However, this term is now positive since we are making the plausible assumption that the southern safety level s^* is lower than the interest-maximizing safety level s^{R^*}. The second term is the efficiency channel and the third term is the direct health channel. More safety in the South has a positive effect on interest payments but reduces output and health levels in the North.

We saw above that capital flows increase northern welfare but falling OHS standards can reduce these welfare gains. What remains here on balance? First of all, an increase in southern safety increases interest rates paid on previous investments Δ since $r^*_{s^*} > 0$. As opposed to (3.10), the classic channel here leads to gains for the North: Higher s^* increases returns for investors as higher labour supply in the South increases marginal productivities of capital in the South (by more than lower southern TFP would reduce it). The second, efficiency, channel is negative if the safety level in the North is below its output-maximizing level (i.e. $Y_s > 0$) and if more safety in the South implies capital outflows from the North and thereby a reduction of safety levels in the North, i.e. $\partial s/\partial s^* < 0$. The third channel does not bring good news for the North either: If OHS standards s and thereby the average health level fall, welfare falls through this health channel as well.

For the South, two new terms as compared to (3.11) appear. The second and third term can easily be identified as the efficiency and health channels in the South. Term one is negative; terms two and three are positive: The South loses out due to higher interest payments to the North but gains from efficiency gains in production caused by higher OHS standards and from health per se.

- The conflict between northern and southern unions

There are numerous examples in the media where northern trade unions help establish southern unions. One often mentioned reason is that unions in the South increase southern wages which reduces low-wage competition in the North. Looking at trade union cooperation in more detail, however, some authors have suggested that international cooperation has been rather marginal (see, for example, Northrup and Rowan (1979), Enderwick (1985), pp. 147-154, and the references therein, and Gordon and Turner (2000)). Our model suggests one possible reason why there is actually a conflict between northern and southern unions. Both unions benefit from capital flows. More capital means higher wages and, as a consequence, higher safety levels. Both enter the objective function of unions positively. Building up a union in the South implying higher safety levels results in a capital outflow and northern union members lose out.

3.5 Conclusion

This chapter has introduced a theoretical framework that allows to study the impact of globalization on OHS in the presence of safety-oriented trade unions. This is an important contribution since the international trade literature has largely ignored OHS issues. Some of the main conclusions from the model are:

International differences in OHS levels caused by trade unions setting high standards in the North can lead to more or less capital in the North relative to a situation where unions are absent. If unions in the North are moderate, capital flows to the South will be reduced (compared to an economy without unions) as some level of health is better than none and marginal productivities of capital are higher with unions. Clearly, if unions put a lot of emphasis on health or even when the social planner maximizes welfare, some capital will be driven out of the country due to high OHS standards - but still less than in a laissez-faire economy. Capital outflows from the North to the South reduce safety standards in the North.

When unions become active in the South, output in the world as a whole will rise and so will welfare. There are strong distributional effects, however, and the North might lose out, as will unions in the North. These distributional effects point to the potentially beneficial effects of side payments from unions in the South to unions in the North. If this cooperation can be achieved, Pareto gains from globalization should be possible.

This chapter has various shortcomings which can be overcome in future work. Capital is not produced in our static model and is therefore highly rivalrous between the North and the South. In this sense, the effects presented so far neglect positive growth effects which would result from higher health levels in the South. A dynamic analysis could take this into account and probably draw an even more optimistic picture of higher safety levels in the South. Second, what happens if unions are allowed to set or bargain wages? Is the positive effect of better OHS standards in the South undone by the labour supply distortion? Third, how do strategic interactions between a union in the North and one in the South with endogenous safety levels in both countries affect our conclusions? Fourth, and maybe most importantly, the theoretical assumption that equilibrium safety standards (set by unions or a government agency) are lower than standards which maximize returns to capital owners should be formulated in a way which allows for empirical testing. All of this is left for future work.

Chapter 4

Why do unionized workers have more nonfatal occupational injuries?

> "There remain two puzzling results of the estimation of our model of coal mining injuries. The first of these is the fact that unionized mines have higher non-fatal accident rates than would be expected for non-union mines with the same characteristics. [...]" (Boden 1977: 139)
>
> "The absence of any evidence of a significant union reduction of hazards runs counter to the conclusion one might draw on the basis of one's observation of actual union actions." (Viscusi 1979a: 231)

4.1 Introduction

Most empirical studies suggest that unionized workers are *more* likely to have a nonfatal occupational injury than their nonunion counterparts. This result has puzzled researchers for more than three decades (as the quotes above illustrate[1]) since it clearly contradicts expectations based on anecdotal evidence and on unions' activities.

This chapter has three main goals: to summarize the empirical literature studying the impact of unions on occupational injuries, to provide new estimates of this impact using individual-level panel data for the first time, and to explain why unionized workers are more likely to have a nonfatal occupational injury. On the first goal, I find that unions are associated with more nonfatal occupational injuries in 27 of the 32 estimates considered in my literature summary. More surprisingly, of the five estimates that associate unions with less nonfatal occupational injuries, only one single estimate is statistically significant. On the second goal, my own estimates

[1] See also Chelius (1974: 727), Boden (1985: 500), Fishback (1986: 290), Fairris (1992: 205), Reardon (1996: 239), Smitha et al. (2001: 1007), and Robinson and Smallman (2006: 101).

using individual-level panel data confirm the puzzling pattern from the existing literature. In particular, my estimates suggest that union members are at least 29% more likely to have a nonfatal occupational injury than their nonunion counterparts. For injuries with several days of incapacity, the injury gap between union and nonunion members is considerable higher than 29%.

These empirical results are in stark contrast with the anecdotal evidence that attributes trade unions an influential role in improving occupational health and safety. Some authors have for example stressed the importance of unions in the development and passage of government legislation such as the Occupational Safety and Health Act in 1970 (Schurman et al. 1998: 134-6). Other prominent examples of unions' safety-enhancing activities include gaining recognition for occupational diseases caused by exposure to coal dust (Smith 1987), cotton dust (Botsch 1993), asbestos (Rosner and Markovitz 1991), radium (Clark 1997), and dibromochloropropane (Robinson 1991).

In more general terms, trade unions are believed to influence occupational health and safety outcomes in several important ways. These include the provision of job hazard information, the protection of workers who refuse to accept hazardous assignments, and the assistance and representation of workers in accident compensation claims. Moreover, apart from influencing the regulatory process and its enforcement, unions bargain for the provision of protective equipment, for compensatory wages, and for the establishment of joint union-management health and safety committees.[2]

What could explain such a dramatic divergence between anecdotal and empirical evidence? Providing an answer to this question is the third goal of this chapter. I first explore the three explanations with the most consensus in the literature which I label as "reporting", "causality", and "wages for safety". First, according to the **reporting** explanation, unions are believed to reduce the number of *actual* nonfatal injuries but also to increase the number of injuries that are *reported*. Since most data sources are not based on actual but on reported injuries, unions appear to be associated with more injuries in most of the cases. Second, proponents of the **causality** explanation argue that the positive association between unions and more nonfatal injuries is because unions are more likely to organize hazardous workplaces and not because unions are causing more injuries. Finally, the **wages-for-safety** explanation suggests that unionized workers simply prefer higher wages than safer workplaces. Accordingly, unions campaign for higher wages but management reacts to this by reducing investment in occupational health and safety.

[2] See Robinson (1991: 40), Beaumont (1983: 2), Viscusi (1979a: 230-1), Dorman (1996: 131-4), and Schurman et al. (1998).

As a result, unionized workers are paid higher wages at the expense of having more injuries.

Using panel data from the National Longitudinal Survey of Youth 1979 (NLSY79), I provide clear empirical evidence against these three explanations. In particular, the union-nonunion injury gap of 29% remains virtually unchanged after accounting for the influence of these explanations. My interpretation is that the puzzle needs to be addressed in a different way.

Accordingly, I propose a novel explanation to this literature that I am labelling **moral hazard** and that looks very consistent with the anecdotal and empirical evidence. The theoretical fundament for this explanation was however already laid down by Viscusi (1979b), Rea (1981), Carmichael (1986), and Lanoie (1991) who argue that workers themselves might offset the benefits of a safer work environment by diminishing their own safety-enhancing efforts. Supported by the anecdotal evidence, I extend this argument by suggesting that it is trade unions that provide or bargain for the safer work environment. The increased safety and protection that unions provide enhance workers' feeling of safety, leading workers to adapt their behaviour, for example, by working faster, becoming bolder, or by taking less safety precautions. This riskier behaviour more than offsets the union safety efforts by increasing the likelihood of a nonfatal injury.

I exploit the panel nature of the NLSY79 data set to provide evidence for the moral hazard explanation. Some of my key results are: The injury probability of a worker increases after one period of unionization, although this increase is not statistically significant. After two periods of unionization, the injury probability increases further, and in this case, the increase is significant. This suggest that workers need some time to adapt to the new safety and protection offered by unions before the moral hazard effect becomes relevant. Moreover, my results also show that when the union protection is over, the moral hazard effect disappears. In fact, I find that workers that quit unions experience an immediate reduction in their injury probability.

The rest of the chapter is organized as follows. Section 4.2 presents the literature summary. Section 4.3 describes the data set and reports my new estimates using individual-level panel data. Section 4.4 assesses the impact of the three major explanations from the literature in explaining the paradox. Section 4.5 introduces and provides evidence for the moral hazard explanation. Section 4.6 summarizes the main conclusions of this chapter.

Table 4.1: Studies investigating the impact of trade unions on occupational injuries

Study	Country	Industry	Years	Data	Cross-sect. unit	Obs.	Union variable	Injury variable (impact)	Explanation given if impact positive and/or insignificant
Chelius (1974)	USA	MA	67	CS	Establishments	2627	COV	NFI (ps)	
Boden (1977)	USA	CM	73-75	PA	Coal mines	6468(?)	MEM	NFI (pi, ps) FAT (ni)	NFI: 1) REP, 2) Labor-management strife, 3) WFS
Viscusi (1979a), app. F.2	USA	SE	69-70	CS	Blue collars	496	MEM	NFI (ps)	CAUS
Leigh (1982)*	USA	SE	77	CS	Blue collars	369	MEM	NFI (ps)	
Worrall and Butler (1983)*	USA	SE	78	CS	Blue collars	2428-2608	MEM	NFI (pi, ps)	REP
Appleton and Baker (1984, 1985)*	USA	CM	79	CS	Coal mines	213	MEM	NFI (ps, ps, ps, pi)	1) Union's job bidding system, 2) Low productivity, 3) Labor characteristics, 4) Other institutional factors
Boden (1985)	USA	CM	73-75	PA	Coal mines	5776	MEM	NFI (ps) FAT (ni)	NFI: REP
Fishback (1986)	USA	CM	12-23	PA	US states	198	MEM	FAT (ni, ni, pi)	1) WFS, 2) Public good aspects of safety may not have been important enough
Fishback (1987)	USA	CM	09-23	PA	US states	264	MEM	FAT (ni)	
Wallace (1987)	USA	CM	30-82	TS	CM industry	53	MEM	NFI (ns) FAT (ns)	
Garen (1988)	USA	SE	81-82	CS	Blue collars	2863	MEM	NFI (ni) FAT (ns)	
Fairris (1992)*	USA	PNS	69-70	CS	Blue collars	381	COV	NFI (pi)	1) CAUS, 2) Union's job bidding system, 3) WFS
Lanoie (1992)	Canada	SE	82-87	PA	Industries	140	MEM	NFI (ps)	REP
Nichols et al. (1995)	UK	MA	90	CS	Establishments	494	COV	NFI (ps)	CAUS
Reilly et al. (1995)*	UK	MA	90	CS	Establishments	432	MEM	NFI (pi)	Variable used captures inadequately impact of unions on occupational health and safety

(*continued on next page*)

Table 4.1: (*continued*)

Study	Country	Industry	Years	Data	Cross-sect. unit	Obs.	Union variable	Injury variable (impact)	Explanation given if impact positive and/or insignificant
Reardon (1996)*	USA	CM	86-88	PA	Coal mines	10808	MEM	NFI+FAT (ni)	1) Union reduces probability of severe NFI by increasing reporting of less severe NFI, 2) Nonunion firms, in an attempt to remain nonunion, improve health and safety, 3) Union's safety committees and inspectors are not efficacious, 4) CAUS
Hillage et al. (2000), app. C	UK	SE	98	CS	Establishments	1982	MEM	NFI (ps)	
Eaton and Nocerino (2000)	USA	PS	88-89	CS, PA	Workplaces	213	UR	NFI (pi, ni)	REP
Litwin (2000)*	UK	SE	98	CS	Workplaces	1640	MEM	NFI (ps)	1) WFS, 2) REP, 3) CAUS
Thomason and Pozzebon (2002)	Canada	SE	95	CS	Firms	424	MEM	NFI (ps)	REP(?): Union workers file more compensation claims
Fenn and Ashby (2004)*	UK	SE	98	CS	Establishments	1636-1749	MEM	NFI (ps, pi, pi, ni)	1) REP, 2) More generous sick pay arrangements in union workplaces
Gray and Mendeloff (2005)	USA	MA	92-98	PA	Establishments	50276	MEM	NFI (ni)	
Robinson and Smallman (2006)	UK	MA, SV	98	CS	Establishments	1585-1597	MEM	NFI (ps, ps)	REP
Nichols et al. (2007)*	UK	MA	90	CS	Establishments	426	MEM	NFI (pi)	1) REP, 2) CAUS
Boal (2008, 2009)*	USA	CM	02-29	PA	US states	210	MEM	FAT (ns)	
		CM	1897-1928	PA	Coal mines	5779-7486	COV	NFI (pi) FAT (ns)	NFI: REP

Notes: * denotes that study focuses primarily on impact of unions on injuries. SHORTCUTS: **Industry**: coal mining (CM), manufacturing (MA), private nonagricultural sector (PNS), public sector (PS), several (SE), service (SV). **Data**: cross-sectional (CS), panel (PA), times series (TS). **Union and injury variables**: coverage (COV), membership (MEM), union resources (UR), nonfatal injury (NFI), fatal injury (FAT). **Impact of unions on injuries**: positive (p), negative (n), significant at the 5% level (s), and insignificant (i). **Explanation impact**: reporting (REP), causality (CAUS), wages for safety (WFS).

4.2 Evidence from the empirical literature

This section surveys the empirical literature investigating the impact of trade unions on occupational injuries. This literature usually estimates an equation of the form

$$INJURY = \beta\, UNION + \mathbf{X}'\boldsymbol{\gamma} + u, \tag{4.1}$$

where $INJURY$ is some measure of the number or frequency of occupational injuries, $UNION$ is a variable indicating union status, $\mathbf{X}$ is a vector of control variables, and u is the error term. The impact of unionism on occupational injuries is thus given by the estimate of β. Based on the anecdotal evidence and on the unions' activities briefly summarized in the introduction, one should expect unions to have a significant impact in reducing injuries, that is, the β coefficient is expected to be *negative* and significant.

Table 4.1 summarizes 25 studies estimating some variation of (4.1). As can be seen from the table, there is a remarkable heterogeneity between these studies, encompassing different countries, industries, years considered, data types, cross-sectional units, number of observations, and measures of the $UNION$ and $INJURY$ variables. The most important result for the purposes of this section is, however, given in column 9. This column summarizes the type of $INJURY$ variable used in each study and, in parenthesis, the impact that the $UNION$ variable had on injuries. Only the estimates that used a measure of fatal (FAT) or nonfatal injuries (NFI) for the $INJURY$ variable were included in the table.[3] Note that some authors reported multiple estimates of β. This is typically done to experiment with different regression specifications, for sensitivity analysis, or when different dependent variables or data sets are employed. For each different $INJURY$ variable, I chose the estimates that the author seemed to judge as the best, giving a total sample of 43 observations. Some key proportions of the final sample are summarized in Table 4.2.

In order to compactly illustrate the union impact on injuries based on the estimates summarized in column 9 from Table 4.1, I created a variable called sigscale using the p-values associated to each β coefficient according to the following formula

$$\text{sigscale} = \begin{cases} 1 - p & \text{if } \beta > 0 \\ -(1-p) & \text{if } \beta < 0 \end{cases}$$

[3] All studies containing only estimates using a different $INJURY$ measure like the severity of the injuries, workers' compensation claims or benefits, or working conditions were excluded from the table.

Table 4.2: Key proportions of the 43 estimates from the literature

Country		**Industry**		**Data**	
USA	70%	Coal mining	44%	Cross-sectional	58%
UK	26%	Manufacturing	12%	Panel	37%
Canada	5%	Other	44%	Time series	5%
Aggregation		**Union variable**		**Injury variable**	
Individual	16%	Membership	84%	Nonfatal injuries	74%
Establishment	65%	Coverage	12%	Fatalities	26%
Industry	7%	Other	4%		
US states	12%				

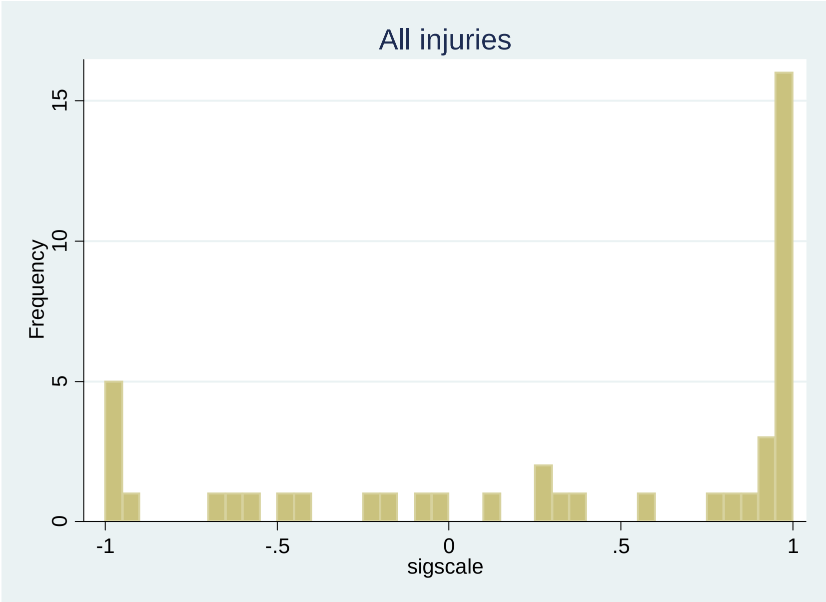
Notes: "Individual" includes blue collars, household heads, and workers. "Establishment" also includes coal mines, workplaces, and firms.

Since the range of the p-value is between zero and one, the range of sigscale is between -1 and 1. Remember that, loosely speaking, β is the "more significant", the lower the p-value is. Moreover, the null hypothesis that β is insignificant (i.e. $\beta = 0$) is usually rejected when $p < 0.05$. As a consequence, β is negative and significant if sigscale $\in [-1, -0.95]$ and β is positive and significant if sigscale $\in [0.95, 1]$. Put simply, the lower the sigscale is, the more negative and significant β is, and the higher the sigscale is, the more positive and significant β is.

Figure 4-1 shows a histogram of sigscale based on all 43 estimates. The first bar on the left shows that in 5 of the 43 regressions, β was negative and significant (at the 5% level). In contrast to this, the last bar on the right shows that in 16 of the regressions, β was positive and significant. All bars in between show that in 22 of the cases, β was insignificant. What can we conclude from this histogram? Since, based on anecdotal evidence and unions' activities, we were expecting β to be negative and significant (i.e. we were expecting most estimates to concentrate at left side of the histogram), the results are clearly puzzling. Only in 5 of the 43 estimates, trade unions were significantly associated with fewer injuries.

A very interesting pattern, however, emerges in Figure 4-2 where the sigscales for fatal and nonfatal injuries are considered separately. The left histogram gives a picture that is more according to expectations and suggests that trade unions are in most cases associated with fewer fatalities. In contrast to this, the right histogram gives a very puzzling result suggesting that in most cases trade unions are associated with more nonfatal injuries. In fact, the right histogram indicates that trade unions are positively associated with more nonfatal injuries in 84% of the estimates and of these 60% are statistically significant. More surprising is the fact that the negative and significant association between unions and nonfatal injuries that we were expecting based on anecdotal evidence and unions' activities was found in only one single study!

Figure 4-1: sigscale histogram for all injuries



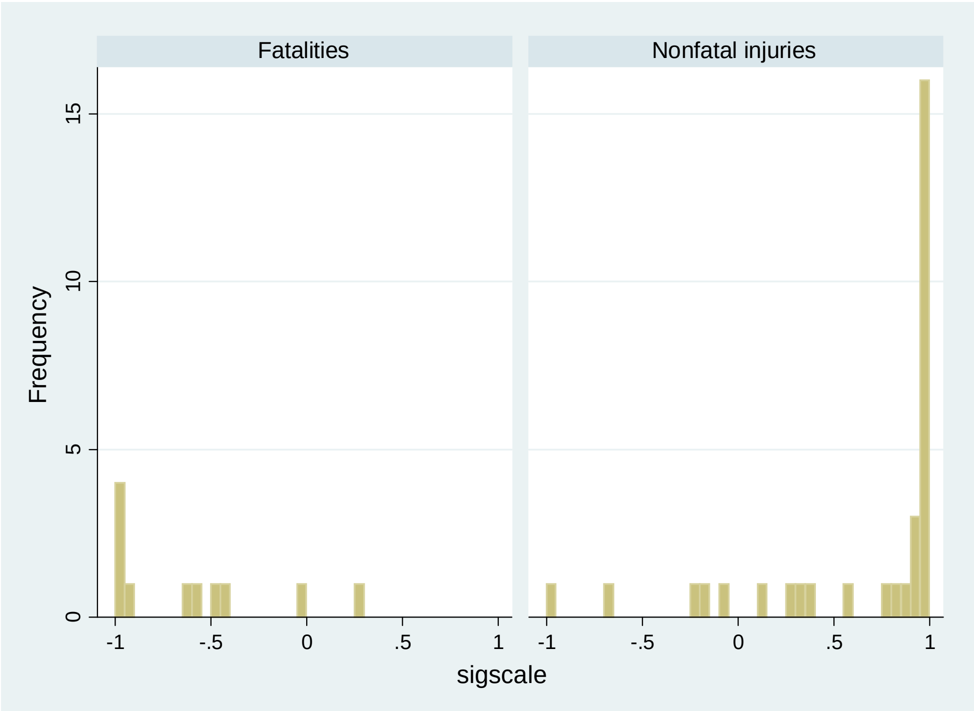
The most important conclusion that I draw from the existing empirical literature is, therefore, that the impact of unions on injuries appears to be different depending on the type of injury studied. While the association between unions and nonfatal injuries is in most cases positive, the association between unions and fatal injuries seems to be negative. My expectations regarding the impact of unions on injuries are only (partially) confirmed for fatal injuries. For nonfatal injuries, the empirical literature clearly contradicts most expectations based on anecdotal evidence.

4.3 New evidence from individual-level panel data

This section extends the empirical literature by providing estimates of the injury-union equation (4.1) using panel data at the individual level for the first time. The data come from the National Longitudinal Survey of Youth 1979 (NLSY79). This survey was administered for the first time in 1979, interviewing a sample of 12,686 American young men and women aged between 14 and 22 years. Until 1994, the cohort was interviewed every year. Since then, the survey has been conducted on a biennially basis. The analysis was restricted to the years for which information was available for all relevant $INJURY$ and $UNION$ variables. These years are 1988, 1989, 1990, 1992, 1993, 1994, 1996, 1998, and 2000, corresponding to the period in which the respondents were aged between 23 and 44 years.

The major advantage of this survey is that it provides detailed data on occupational injuries, on union status, and on an extensive set of questions on personal and job characteristics. The

Figure 4-2: sigscale histograms by type of injury



richness of the NLSY79 data makes possible to study the union impact on injuries at a depth that has not been possible before using other data sets. There are at least three reasons for this. First, as Table 4.1 shows, all previous estimations at the individual level were based on cross-sectional data. This type of data has several limitations. In particular, it only allows to make comparisons across individuals, and it is not possible to follow the same person over time. As we will see in section 4.5, it is only with panel data at the individual level that is possible to study moral hazard issues. Second, in none of the data sets used before there was information on both $INJURY$ and $UNION$ variables. Researchers were obliged to match injury rates at the industry level from another data source to each individual for which they had information on their union status and other characteristics. The NLSY79, however, allows to calculate the probability of having an injury based on each individual's own experience and not on an average of the industry where they work. Third, the NLSY79 data set is the only one that has information on both union membership and on union coverage. This gives us two possibilities for measuring the $UNION$ variable.

Summary statistics for the $INJURY$ and $UNION$ variables used to estimate the injury-union equation (4.1) are reported (among other variables) in Table 4.3. The $INJURY$ variable is based on a question on nonfatal injuries (NFI). As Table 4.3 shows, on average, 6% of the respondents reported having had a nonfatal work-related injury or illness in the period considered.

The variables used to measure union status are union membership (MEMBERSHIP) and union coverage (COVERAGE). In general, not all workers covered by a union contract are members of a union. In fact, as Table 4.3 illustrates, an average of 18.7% of the respondents was covered by a union contract while only 14.2% was member of a trade union.

Table 4.3: Summary statistics and definitions of some key variables

Variable	Definition	Mean	Std. Dev.	Min	Max	Obs.
NFI	1 if any work-related injury or illness	0.060	0.237	0	1	71717
COVERAGE	1 if covered by union contract	0.187	0.390	0	1	63199
MEMBERSHIP	1 if in union or employee association	0.142	0.349	0	1	63147
SEVERITY	Number of work days missed due to NFI	23.52	82.31	0	996	4245
COMPFORM	1 if worker's compensation form filled out for NFI	0.569	0.495	0	1	4258
DANGEROUS88	Job is dangerous on a scale of 1 to 4 (worst)	1.947	1.061	1	4	9135
UNHEALTHY88	Unhealthy working conditions on a scale of 1 to 4 (worst)	1.785	0.991	1	4	9130
INDUSTRYRISK	Log of injury and illness cases per 10000 full-time workers by industry	6.551	0.697	2.996	8.261	62625
MALE	1 if male	0.505	0.500	0	1	114174
BLACK	1 if black	0.250	0.433	0	1	114174
HISPANIC	1 if Hispanic	0.158	0.365	0	1	114174
RETIREMENT	1 if employer made available retirement plan other than social security	0.599	0.490	0	1	63456
MATERNITY	1 if employer made available maternity/paternity leave	0.627	0.484	0	1	60292
DENTALINS	1 if employer made available dental insurance	0.577	0.494	0	1	64351
WAGE	Log of hourly rate of pay	6.850	0.679	0	15.6	69819
CARVALUE	Market value of all vehicles respondent/spouse own	8354	10242	0	76573	85347
RESIDENCEVALUE	Market value of residential property respondent/spouse own	44538	80282	0	834906	83178
HEALTHINS	1 if employer-provided health insurance covering injuries or illnesses off the job	0.759	0.428	0	1	64610
LIFEINS	1 if employer-provided life insurance covering death for reasons not connected with job	0.650	0.477	0	1	63775

Notes: The statistics are for the years 88, 89, 90, 92, 93, 94, 96, 98, and 2000, except for DANGEROUS88 and UNHEALTHY88 that are only for the year 88. The complete definitions of the union status variables are: COVERAGE: "1 if wages set by collective bargaining, or if covered by union or employee contract, or if MEMBERSHIP=1". MEMBERSHIP: "1 if in union or employee association, 0 otherwise. Before 1994 also =0 if COVERAGE=0". In order to attenuate problems with measurement errors, I set SEVERITY and COMPFORM as missing if NFI was missing or if NFI=0.

Table 4.4 presents the fixed-effects estimates of equation (4.1) using the two different union status measures (COVERAGE and MEMBERSHIP) and with nonfatal injuries (NFI) as the outcome variable.[4] The estimated regressions include an extensive list of control variables containing measurements of the individuals' health, job satisfaction, tenure with employer and its square, firm size, hours per week worked, years of education, number of children, age, and dummies for 8 years, marital status, type of residence, 3 regions, 11 industries, and 11 occupations, for a total of 44 control variables[5] (see Table C.1 in the appendix for complete definitions and summary statistics). Only the estimates based on linear probability models are reported in this chapter. Other models, like the logit, yield very similar results but are more difficult to interpret.

[4] A Hausman test clearly rejects the random-effects model.

[5] Gender and race dummies were excluded from the analysis since time-invariant variables are not identified by the estimation techniques used.

Table 4.4: Fixed-effects estimates of equation (4.1)

Variable	Coefficient (1a)	Std. Err. (1b)	Coefficient (2a)	Std. Err. (2b)
COVERAGE	.0159867***	.0042949		
MEMBERSHIP			.0200947***	.0053864
HEALTH	.099714***	.0103364	.0991243***	.0103374
SATISF	-.0097178***	.001964	-.0097429***	.0019653
TENURE	.0001534***	.0000156	.0001525***	.0000156
TENURESQ	-1.32e-07***	1.91e-08	-1.32e-07***	1.91e-08
FIRMSIZE	.0020571***	.0006654	.0020564***	.000666
HOURSWEEK	.0006769***	.0001341	.0006765***	.0001341
EDUCATION	.0003701	.0026725	.0004089	.0026722
CHILDREN	.0038147	.0024959	.0039524	.0024937
AGE	.0034521	.0040438	.0034732	.0040455
MARRIED	.0012079	.0035363	.00133	.0035311
URBAN	-.0061589	.0044312	-.0062591	.0044307
NORTHEAST	-.010984	.0115406	-.011507	.0115751
NORTHCENT	.0009117	.0118063	.0006144	.0118193
WEST	.0025252	.0112414	.002226	.0112456
AGRICU	-.0007706	.0133061	-.0005785	.0133443
MINING	.0075513	.0175448	.0072738	.0175824
CONSTRUC	.0151794*	.0088326	.0151585*	.0088387
MANUF	.0149702***	.005808	.0150065***	.0057976
TRANSP	.0192235**	.0076782	.0191688**	.0076738
TRADE	.0093453*	.0054794	.0094617*	.0054682
FINANCE	-.0024539	.006414	-.0024632	.0064083
PERSONAL	.0020914	.0093128	.0019954	.0093074
ENTERTAIN	.0140815	.0123841	.0130354	.0123801
PROFSERV	.0084455	.0056538	.0086756	.0056429
PUBLIC	.0203146**	.0091772	.0202584**	.0091776
PROFTECH	.0033093	.0041577	.0029703	.0041564
MANAGER	.0048783	.0041377	.0050135	.0041387
SALES	-.0028518	.0053934	-.0029394	.0053959
CRAFT	.0302186***	.0066134	.0302049***	.0066139
OPERAT	.0283185***	.0070269	.0283452***	.0070305
TROPERAT	.0111702	.0100722	.010923	.010091
LABORERS	.0322209***	.007667	.0321734***	.0076679
FARMER	-.0369164	.0275987	-.0376485	.0275567
FARMLAB	-.0170704	.0204094	-.0177183	.0204183
SERVICE	.0158797***	.0054114	.015795***	.0054028
PRIVATE	.0159285	.0178742	.0158443	.017867
CONSTANT	-.0617944	.1155228	-.0621333	.115587
Nonunion baseline	0.058		0.059	
Injury gap	27%		34%	
Observations	56893		56848	
R^2	0.0261		0.0264	

Notes: The table reports fixed-effects estimates of equation (4.1) using the two different union status measures COVERAGE and MEMBERSHIP. The outcome variable is NFI. Both estimates are based on linear probability models and also include 8 year dummies as additional controls. All standard errors are cluster robust. The "nonunion baseline" is computed as the average predicted probability of the outcome variable using the estimated coefficients on the control variables. The "injury gap" is the percentage increase in the injury probability of nonunion member to union member. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4.4 gives a very clear picture of the impact of trade unions on nonfatal occupational injuries. Irrespective of the $UNION$ measure used, unions are clearly associated with *more* nonfatal injuries, after controlling for the extensive set of personal and job characteristics. The COVERAGE and MEMBERSHIP coefficients are positive and highly significant, confirming and reinforcing the pattern from the empirical literature summarized in the previous section. Note also that the COVERAGE and MEMBERSHIP estimates remain robust to other model specifications and if more or less control variables are included.

Turning to the interpretation of the $UNION$ estimates, the probability of having an occupational injury is 0.016 higher for covered workers and 0.02 higher for union members. These values are not small. In fact, one way to put these values into perspective is by comparing them with the "nonunion baseline" values also reported in Table 4.4. The nonunion baseline is the average predicted injury probability of the nonunion workers. Adding the $UNION$ estimates to the nonunion baseline values gives the average predicted injury probability of the union workers, which are $0.058 + 0.016 = 7.4\%$ for covered workers and $0.059 + 0.02 = 7.9\%$ for union members. The table also reports the "injury gap", which is the percentage increase in the injury probability for union compared to nonunion workers. The injury gap thus indicates that the probability of having an occupational injury increases by 28% for workers that change their union status from not covered to covered and by 34% if they change from nonmember to member.[6]

4.4 Explanations from the literature

The results from the previous two sections provide clear evidence of the positive association between trade unions and nonfatal injuries. In this section, we will try to understand why. As the last column in Table 4.1 shows, the literature has suggested several explanations for this paradoxical result. There are, in particular, three explanations that appear to be gaining some consensus among researchers. From the 25 studies summarized in Table 4.1, "reporting" was mentioned in 11 studies, "causality" in 7 studies, and "wages for safety" in 4 studies. This section will explore these three explanations in turn.

4.4.1 Reporting

The explanation most often mentioned in the literature is reporting. According to this explanation, unions are believed to reduce the number of *actual* nonfatal injuries but also to increase the number of injuries that are *reported*. Since most data sources are not based on actual but on reported injuries, unions appear to be associated with more injuries in most of the cases.

There are at least two reasons why unions might increase the number of reported injuries. First, at the establishment level, unions might better monitor the reporting of injuries by employers. In fact, firms have an incentive to underreport injuries for different cost-saving reasons, for example, to reduce paperwork, to maintain lower insurance premia in the workers' compensation system, or to avoid triggering safety inspections from governmental authorities (Leigh et al.

[6] In what follows, I will not always report the estimates based on the COVERAGE variable. These estimates are qualitatively the same to those using the MEMBERSHIP variable but the resulting injury gap is smaller.

2004: 11). Second, at the individual level, unionized workers might simply report more injuries because they might be less fearful of management retaliation. In fact, "[w]orkers who report health problems to supervisors may risk disciplinary action, denial of overtime or promotion opportunities, stigmatization, drug testing, harassment, or job loss." (Azaroff et al. 2002: 1422) Union members often enjoy a better protection against these types of retaliation.

Are the estimates based on the NLSY79 data set affected by less underreporting in unionized workplaces? I argue here that this is not the case. By construction, this data set is very different to all previous data sets that have been used in the literature to estimate the injury-union regression (4.1).[7] The NLSY79 data set is not based on information provided by firms, which have an incentive to underreport injuries, but by individuals during a private interview. Many different questions are asked to these individuals, which range from school attendance to family composition, and there is no apparent reason for them to give inaccurate information on potential occupational injuries. I use this different data construction as an argument against the "reporting" explanation and argue that the estimates in Table 4.4 are not affected by underreporting.

There is however one problem with this interpretation of the results. It is often the case that workers do not perceive some of the hazard risks in their workplace and better-informed unionized workers might be more likely to report an injury to the NLSY79 interviewers, simply because they are more aware of safety issues and not because they are having more injuries. In fact, some occupational injuries or illnesses take some time to manifest, and workers are not always sure if their workplace was at the origin of the injury or illness. One of the unions' safety activities is to provide workers with job hazard information. In that sense, if a unionized worker is more likely to report an occupational injury to the NLSY79 interviewers, the estimates of the injury gap in Table 4.4 would be biased upwards. Notice that this "information advantage" of union members is different to the "reporting" explanation from the literature. The literature uses reporting to explain that actual injuries, *of which workers and management are aware*, are not being reported because firms have cost-saving incentives to underreport them.

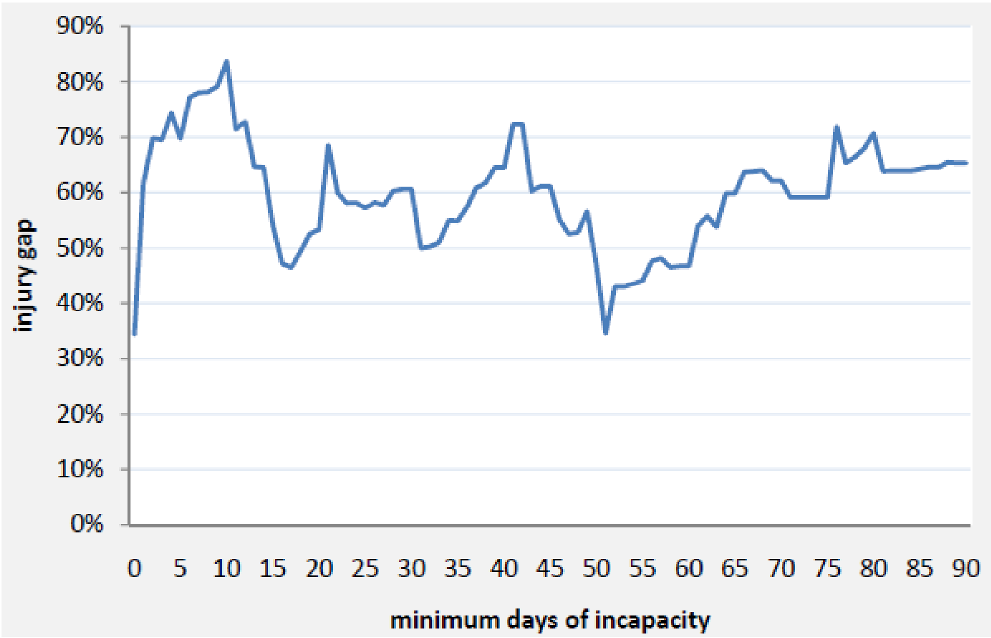
One possibility to asses if the results in Table 4.4 are biased upwards because of union workers' information advantage is to estimate the injury-union regression (4.1) for more severe injuries. In fact, it seems reasonable to assume that the knowledge advantage is lower, the more severe an injury is. More visible or severe injuries are more likely to be recognized by a worker that is not unionized. The information advantage bias should narrow, the more severe an injury

[7] The only exception is one of the two estimates with nonfatal injuries as the outcome variable from Worral and Butler (1983). They use for this a measure of actual, not reported, injuries.

is. Fortunately, the NLSY79 also asks respondents to indicate the number of work days missed due to the occupational injury. This variable, which I am calling SEVERITY (see Table 4.3 for definition and summary statistics), can be used to estimate the injury gap for different severity degrees.

Figure 4-3 plots the injury gaps that resulted from estimating regression (4.1) for different injury severity degrees. For at least zero days of incapacity, we obtain the injury gap of 34% that was already reported in column (2a) of Table 4.4. Moving to the right in the figure gives injury gaps corresponding to more and more severe injuries. For example, for at least 5 days of incapacity, the injury gap increases to 70%. For at least 60 days of incapacity, the injury gap is 47%. If the estimates were biased upwards due to an information advantage bias, we would expect a graphic with a falling trend. The graphic however exhibits no discernible trend, and the estimates do not appear to be biased, at least for the range of severity considered.[8]

Figure 4-3: Injury gaps for different injury severity degrees



Even if the figure does not seem to provide evidence of an information advantage bias, the NLSY79 offers a alternative possibility to try to estimate this bias. In fact, there is one question from the NLSY79 that can be of some help. If a worker reported having had an occupational injury, he was then asked if he filled out a workers' compensation form for this injury. One of unions' safety activities is to provide workers with information on how and when

[8]The SEVERITY variable does include information on injuries resulting in more than 90 days of incapacity. Since these types of injuries do not occur very often, the sample is very small and the estimates based on them are very imprecise.

to apply for workers' compensation. The empirical literature confirms that union workers are more knowledgeable of the workers' compensation procedures and that they are more likely to apply for compensation after an injury (Butler and Worrall 1983). It is therefore possible to estimate how more likely are union workers to apply for compensation and use this as a proxy for the information advantage bias. The problem with this proxy, however, is that it might not only capture more knowledge but also other advantages of unionization like workers' less fear of potential management retaliation when filling a compensation form. The information advantage bias computed in this fashion should therefore be better regarded as an upper bound of the true bias.

Table 4.5 reports the $UNION$ fixed-effects (FE) and random-effects (RE) estimates of an equation similar to (4.1), adjusting for the full set of control variables, but with COMPFORM as the outcome variable. Definition and summary statistics of COMPFORM are provided in Table 4.3. Only the RE estimates are significant. However, since a Hausman test could not reject the RE model for this regression, I will only focus on the RE estimates in what follows. Turning to the interpretation of the results, the probability of filling out a compensation form for nonunion workers is the "nonunion baseline" which is equal to 55.2%. Adding the $UNION$ estimates of 0.090 to the nonunion baseline gives the probability for the union workers which is equal to 64.2%. Finally, the "information advantage bias" of 16% is computed as the percentage increase in the probability of filling out a compensation form for union compared to nonunion workers.

Table 4.5: Computing the "information advantage bias"

	FE	RE
$UNION$	0.079	0.090
	(0.075)	(0.023)***
Controls?	Yes	Yes
Nonunion baseline	0.559	0.552
Information advantage bias	14%	16%
Observations	3463	3463

Notes: The table reports fixed-effects (FE) and random-effects (RE) estimates of the $UNION$ coefficient in an equation similar to (4.1) but with COMPFORM as the outcome variable. The union status variable is MEMBERSHIP. Both estimates are based on linear probability models and include the full set of control variables defined in Table C.1 plus 8 year dummies and the SEVERITY variable. Standard errors in parenthesis are cluster robust. The "nonunion baseline" is computed as the average predicted probability of the outcome variable using the estimated coefficients on the control variables. The "information advantage bias" is computed as the percentage increase in the probability of filling out a workers' compensation form after an occupational injury for nonunion members with respect to union members. *** p<0.01, ** p<0.05, * p<0.1.

The estimated "information advantage bias" of 16% can be used to correct the injury gap of 34% reported in column (2a) of Table 4.4. The resulting "unbiased" union-nonunion injury gap is 29%. This suggests that even after accounting for a possible union workers' information advantage, the paradoxical positive injury gap between union and nonunion workers should remain positive.

4.4.2 Causality

As the literature summary in Table 4.1 shows, the second most important explanation after reporting (REP) is causality (CAUS). The causality explanation can be given two interpretations. The first interpretation is that the $UNION$ variable might also be capturing the impact of workplace risk, suggesting that the $UNION$ estimates are positive because union workplaces are riskier and not because unions are causing more injuries. The second interpretation is that the causality of $UNION$ and $INJURY$ might run in both directions. Unions might cause more injuries, but more injuries (or more hazardous workplaces) might also cause workers to form or join unions. Failing to take into account this double causality might produce estimates that lead to the wrong conclusions. This section employs two different strategies to test each of these interpretations. The first strategy is to control for workplace risk. The second is to use instrumental variable methods to isolate the causal impact of unions on injuries.

Controlling for workplace risk

If the $UNION$ variable is also capturing workplace risk, then the natural extension of the injury-union regression (4.1) is to include a new control variable that accounts for the average risk of the workplace where the worker is employed. In that way, the $UNION$ coefficient can be "cleaned" from this influence.

Table 4.6 reports the estimates of the injury-union regression (4.1) that also control for workplace risk. In columns (1) and (2) the workplace risk variables are two questions from the NLSY79 that ask respondents to rate, on a scale of one to four, how dangerous (DANGEROUS88) and how unhealthy (UNHEALTHY88) their job were (see Table 4.3 for definitions and summary statistics). Unfortunately, these questions were only asked in 1988, and the estimates reported in columns (1) and (2) are OLS for this year only.

In order to be able to exploit the panel nature of the NLSY79 data set by controlling for changes in workplace risk *over time*, I used a variable from a different data set that was available for all the years of the NLSY79 sample. The data for this new variable are based on the incidence rates from the Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses. The incidence rates are defined as the number of nonfatal occupational injury and illness cases per 100 full-time workers. These incidence rates are available for more than 200 industries for every year of the NLSY79 sample and represent a very good proxy of the average risk in each industry. These rates were transformed by multiplying them by 100 and by taking the log in order to obtain the final INDUSTRYRISK variable (see Table 4.3 for definition and summary statistics). Since the NLSY79 respondents also report the detailed industry where they work, it is possible to match the (transformed) BLS incidence rates to the NLSY79 respondents based on the industry codes provided in both data sets.[9] The $UNION$ fixed-effects estimates that also control for the INDUSTRYRISK variable are reported in Table 4.6, column 3.

Table 4.6: Estimates of the injury-union regression controlling for workplace risk

	(1) DANGEROUS88	(2) UNHEALTHY88	(3) INDUSTRYRISK
$UNION$	0.028	0.029	0.020
	(0.012)**	(0.013)**	(0.006)***
Workplace risk	0.041	0.033	0.005
	(0.004)***	(0.004)***	(0.003)*
Controls?	Yes	Yes	Yes
Observations	7209	7207	49389

Notes: The table reports estimates of the $UNION$ coefficient in equation (4.1) only for the union status measure MEMBERSHIP. The outcome variable is always NFI. All estimates are based on linear probability models. The estimates in columns (1) and (2) are OLS and are only for the year 1988. All estimates include the full set of control variables defined in Table C.1 and one of the working condition variables (DANGEROUS88, UNHEALTHY88 or INDUSTRYRISK). The estimates in columns (1) and (2) also include MALE, BLACK and HISPANIC (see Table 4.3 for definitions). The estimates in column (3) are by fixed effects and also include 8 year dummies. Standard errors in parenthesis are cluster robust. *** p<0.01, ** p<0.05, * p<0.1.

The results in Table 4.6 are very clear. Even after controlling for workplace risk, the $UNION$ estimates are positive and significant. The workplace risk variables are also positive and significant, indicating that the quality of working conditions is also an important determinant of occupational injuries. These results provide evidence against this interpretation of the causality explanation.

IV estimates

If the causality between $UNION$ and $INJURY$ is running in both directions, a good starting point to test this interpretation is by estimating an equation that investigates the other side of

[9] The BLS data can be downloaded at ftp://ftp.bls.gov/pub/time.series/sh/ and at ftp://ftp.bls.gov/pub/time.series/hs/. Each NLSY79 respondent was matched to the (transformed) BLS incidence rates based on the respondents' reported industry code at the most precise level of industry breakdown that the two data sets allowed to. In many cases, this was at the three-digit level. Due to data limitations, however, it was not possible to assign every NLSY79 respondent to a particular industry-risk group. For example, the BLS survey does not provide incidence rates for the public administration sector. Despite these limitations, it was possible to construct more than 200 industry-risk groups for every year. The BLS data are based on the Standard Industrial Classification (SIC) System from 1972 and 1987, while the NLSY79 respondents are coded using the 1970 and the 1980 industry classification system of the Census of Population. The two data sets were merged using concordance tables that relate both classification systems to each other.

the causality, that is, the impact of having had an injury on the probability of becoming a union member:

$$UNION = \beta_{UI}\ INJURY + \mathbf{X}'\boldsymbol{\gamma} + u. \tag{4.2}$$

The anecdotal evidence suggests that workers have traditionally favoured union membership as a mechanism to reduce workplace hazards. According to this evidence, β_{UI} is expected to be positive and significant. My own estimates of β_{UI} (not reported in this chapter) based on a linear probability model by fixed effects and including the full set of control variables were positive and highly significant, suggesting that the hazardousness of a workplace might indeed be important when deciding to join a union. These results are also supported by other empirical studies. Hirsch and Berger (1984) and Martinello and Meng (1992), for example, find that higher average industry injury rates significantly increase the likelihood of unionization. Duncan and Stafford (1980) find the same pattern but not for injury rates but for working conditions in general. Moreover, Robinson (1988, 1990) provides evidence that individuals working under hazardous conditions are significantly more likely to vote for union representation.

These results and those reported in Table 4.4 seem to confirm that the relationship between unions and injuries might be a simultaneous one. In such a case, the model can be specified as a system of two equations using (4.1) and (4.2). This de facto acknowledges the endogeneity of the $UNION$ variable in (4.1).

According to one of the definitions of endogeneity, the $UNION$ variable is endogenous if it is correlated with the error term u in equation (4.1). This error term can be viewed as having two components, one time-variant ε_t and one time-invariant α, so that $u_t = \alpha + \varepsilon_t$, where t indexes time. The fixed-effects estimation approach that I used to estimate (4.1) already controls for union endogeneity if $UNION$ is correlated only with the time-invariant component of the error.[10] In other words, if $UNION$ is only correlated with α, the estimates presented in Table 4.4 are indeed giving the size of the *causal* union impact on injuries.

However, what if $UNION$ is correlated with the time-variant component of the error? A stricter approach that controls for this type of union endogeneity is based on instrumental variable techniques. In fact, one way to break the simultaneity and to find the causal impact of union on injuries is by estimating only (4.1) but by using an instrument for the $UNION$ variable. A valid instrument has to satisfy two conditions. First, the instrument itself has to be uncorrelated with the error term u in (4.1). And second, the instrument must be partially correlated with the

[10] See Wooldridge (2002) and Cameron and Trivedi (2005) for more details on this and on the estimation techniques used in this chapter.

$UNION$ variable after controlling for the remaining exogenous regressors.

This type of exercise has been performed before in three of the empirical studies from the literature in Table 4.1, but in all cases using not panel but cross-sectional data. Moreover, all three studies employed British data at the establishment level. Fenn and Ashby (2004: 475-6) and Robinson and Smallman (2006: 94) worked with the same British data set and used the same instrument to test for possible endogeneity of the $UNION$ variable. Their tests failed to reject the null hypothesis of union exogeneity, suggesting that their estimates without controlling for union endogeneity were valid and unions were indeed significantly *causing* more nonfatal injuries. Contrary to this, Nichols et al. (2007: 218) found that endogeneity was present. Their results after controlling for endogeneity were also positive but insignificant.[11]

The NLSY79 data set offers at least two possibilities to instrument for the $UNION$ variable. The first possibility is based on empirical evidence suggesting that unionized workers receive better fringe benefits than their nonunionized counterparts (Freeman and Medoff 1984, ch. 4). Fortunately, the NLSY79 has detailed information on fringe benefits which can be used as instruments. Three candidates from the NLSY79 that potentially fulfil the two requirements of a valid instrument are RETIREMENT, MATERNITY, and DENTALINS. Summary statistics and definitions of these variables are provided in Table 4.3.

The second possibility is based on the panel data nature of the NLSY79. In fact, with panel data it is possible to use exogenous regressors in other time periods as instruments for endogenous regressors in the current time period. In particular, assuming that past $UNION$ status is exogenous, we can use lagged levels and lagged differences of the $UNION$ variable to instrument for the current endogenous $UNION$ variable.

Table 4.7 reports the estimates of the $UNION$ coefficient using panel instrumental variables (IV) methods and adjusting for the full set of controls. Columns (1) to (3) show the fixed-effects IV estimates, each respectively using one of the instruments RETIREMENT, MATERNITY, or DENTALINS, while the estimates in column (4) use all these three instruments and are by fixed-effects two-stage least squares (2SLS). Column (5) reports the estimates by the so-called difference Generalized Method of Moments (GMM) using lagged levels of $UNION$ as instruments. Finally, the estimates in column (6) are by the so-called system GMM and use lagged levels and lagged differences of $UNION$ as instruments.

The different instruments produce different $UNION$ estimates, probably reflecting the differ-

[11] Boal (2008: 35) also controlled for union endogeneity but the outcome variable was fatalities and not nonfatal injuries. He found, without performing any endogeneity test and after recognizing the poor quality of his instruments, that the impact of unions on fatalities was insignificant after controlling for union endogeneity.

Table 4.7: Estimates of the injury-union regression controlling for union endogeneity

	(1) IV1	(2) IV2	(3) IV3	(4) 2SLS	(5) diff GMM	(6) sys GMM
UNION	0.209	0.260	0.155	0.188	0.029	0.021
	(0.052)***	(0.087)***	(0.057)***	(0.044)***	(0.016)*	(0.009)**
Instrument(s)	RETIREMENT	MATERNITY	DENTALINS	RETIREMENT MATERNITY DENTALINS	Lagged levels *UNION*	Lagged levels and differences *UNION*
Controls?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	52078	49236	52847	48330	27063	42905

Notes: The table reports estimates of the *UNION* coefficient in equation (4.1) controlling for union endogeneity and only for the union status measure MEMBERSHIP. The outcome variable is always NFI. All estimates are based on linear probability models and include the full set of control variables defined in Table C.1. The estimates in columns (1) to (4) also include 8 year dummies. The GMM estimates in columns (5) and (6) exclude observations for uneven years. For the first differences, on which GMM estimates are based, I assumed that even years were consecutive, and only 6 year dummies were included as additional controls. Standard errors in parenthesis are cluster robust. *** p<0.01, ** p<0.05, * p<0.1.

ent strength of each instrument. However, in terms of the sign of the impact and its significance, Table 4.7 gives a very clear picture. Irrespective of the instrument or estimation technique used, all estimates are positive and significant. These results, and those from the three studies mentioned above, provide compelling evidence that unions are indeed *causing* more injuries.[12]

What can we conclude from this interpretation of the causality explanation? I provided evidence that the causality between $UNION$ and $INJURY$ runs in both directions. However, after controlling for union endogeneity, the impact of unions on injuries remained positive and significant. In particular, the estimates in Table 4.7 give strong evidence that the positive relationship between unions and injuries is not only an association, but that there is also causation from unions to injuries.

4.4.3 Wages for safety

Wages for safety (WFS) is the third most important explanation in Table 4.1. This explanation might be attributed to Duncan and Stafford (1980) who did not consider occupational injuries but working conditions in general. The idea of this explanation is that there are different goals that unions can pursue. Two of them are higher wages and better working conditions. Since both goals are costly from the management's perspective, often unions have to focus their energy on only one of them. If trade unions increase wages, management might react by deteriorating working conditions in order to reduce costs. The explanation thus suggests that unions are

[12] Several formal tests performed to verify the quality of these estimates gave the following results: First, the endogeneity of the union variable could not be rejected. Second, the Hansen test for overidentified restrictions after 2SLS and GMM led to the conclusion that the instruments were valid. And third, the null hypothesis of weak instruments after 2SLS was rejected based on a Wald F-statistic.

associated with more injuries because they favour higher wages at the expense of better working conditions. If working conditions are poor, the number of occupational injuries is high.

In addition to Duncan and Stafford (1980), other authors have suggested that unions have put too much emphasis on wages at the expense of better working conditions. Bacow (1980: 101), for example, affirms that "[h]ealth and safety issues do not command a high position on union bargaining agendas because there is little political return on cleaning up the workplace; changes are often not recognized for years and the individuals most likely to benefit tend to be underrepresented." Nelking and Brown (1984: 117) affirm that "[w]orkers are often frustrated by the limited union influence over hazardous conditions. Preoccupied with bread and butter issues, some local officers regard health hazards as secondary." Moreover, Fishback (1986: 290) argues that "the [United Mine Workers of America] may have devoted more of their efforts to improving wages and organizing nonunion districts than to improving safety."

In order to test the wages-for-safety explanation empirically, it is important to check if unions are really increasing wages in the first place. Using a question on wages from the NLSY79, I estimated an equation of the form

$$WAGE = \beta_{WU}\ UNION + \mathbf{X}'\boldsymbol{\gamma} + u. \tag{4.3}$$

The definition and summary statistics of the outcome WAGE variable are given in Table 4.3. My fixed-effects estimates of β_{WU} (not reported in this chapter) adjusting for the full set of control variables indicated that the wages were 11.5% significantly higher for union members. These results are, however, not new and there is a huge literature confirming them (see for example Lewis 1986). In fact, in this literature the question is not whether unions increase wages but on how much. What is remarkable about these results is that, combining them with the results from Table 4.4, they seem to provide evidence that the same unions that are increasing wages are also increasing the injury probability, giving some support for the "wages-for-safety" explanation.[13]

However, the most rigorous test this explanation still has to pass is if unionization increases the injury probability even after holding wages fixed. In other words, we would like to know the causal impact of unions on injuries after purging it from any effects of unions on wages. The new regression extends (4.1) by including the WAGE variable as one of its regressors. Moreover, since the WAGE and $UNION$ variables are potentially endogenous, instrumental variable methods might be needed to estimate this extended regression.

[13] Some authors have suggested that part of the wage premium that unionized workers receive is a compensation for their higher injury probability (see Duncan and Stafford 1980). This seems to be supported by the empirical literature (see Schurman et al., 1998: 131, and the references therein).

Three studies from the empirical literature in Table 4.1 have estimated an injury-union regression holding wages fixed. All of them used cross-sectional data at the establishment level. Thomason and Pozzebon (2002, Table 6: "Total Sample") and Chelius (1974: 717-21, 728) find a positive and significant union impact on injuries, but only Chelius controls for wage endogeneity. Fenn and Ashby (2004), after rejecting the endogeneity of wages (pp. 473-5), find that the union impact is positive and significant for illnesses and positive but insignificant for injuries (Table 2). In all three studies the WAGE coefficient was insignificant.[14]

Using the NLSY79 it is also possible to control for WAGE endogeneity. To instrument for WAGE, I used two questions that ask respondents to estimate the market value of all vehicles owned (CARVALUE) and to estimate the value of their residential property (RESIDENCEVALUE). Summary statistics of these variables are provided in Table 4.3. Table 4.8 reports the $UNION$ estimates. The first column gives the fixed-effects estimates without controlling for endogeneities. Columns (2) and (3) report the IV fixed-effects estimates after controlling only for WAGE endogeneity, while (4) also controls for $UNION$ endogeneity.

Table 4.8: Estimates of the injury-union regression controlling for wages

	(1) FE	(2) IV1	(3) IV2	(4) IV3
$UNION$	0.019	0.020	0.020	0.224
	(0.005)***	(0.008)**	(0.007)***	(0.097)**
WAGE	0.007	-0.002	0.0004	-0.015
	(0.002)***	(0.050)	(0.040)	(0.048)
Instrument				
for WAGE		CARVALUE	RESIDENCEVALUE	RESIDENCEVALUE
for $UNION$				RETIREMENT
Controls?	Yes	Yes	Yes	Yes
Observations	55472	54465	54455	50711

Notes: The table reports estimates of the $UNION$ coefficient in equation (4.1) that also control for wages. The union variable is always MEMBERSHIP and the outcome variable is always NFI. All estimates are based on linear probability models and include the full set of control variables defined in Table C.1 plus 8 year dummies. The estimates in columns (2) and (3) also control for wage endogeneity respectively using the instruments CARVALUE and RESICENCEVALUE. The estimates in column (4) also control for wage and union endogeneity using the instruments RESICENCEVALUE and RETIREMENT. Standard errors in parenthesis are cluster robust. *** p<0.01, ** p<0.05, * p<0.1.

Let us first consider the impact of wages on injuries. According to the "wages-for-safety" explanation, an increase in wages should be followed by an increase in the injury probability. This idea seems to be confirmed by the results in column (1), since the WAGE coefficient is positive and highly significant. However, after controlling for $UNION$ and WAGE endogeneity, the sign of the coefficient is sometimes reversed and becomes insignificant. The WAGE coefficient in all three studies mentioned above was also insignificant.

[14] Fishback (1986) also estimated an injury-union regression holding wages fixed but his outcome variable was a measure of fatalities and not of nonfatal injuries.

Turning to the union impact on injuries, Table 4.8 gives a very clear picture: All estimates of the $UNION$ coefficient are positive and significant, even after holding wages fixed and controlling for $UNION$ and WAGE endogeneity. These results, together with the estimates from the three studies mentioned above, provide solid evidence against the "wages-for-safety" explanation.

4.5 The new explanation: Moral hazard

The previous section provided clear empirical evidence against the three traditional explanations from the literature. In this section, I argue that the paradox can be solved by applying the concept of moral hazard. In fact, moral hazard explains why unionized workers are having more occupational injuries despite all the safety-enhancing efforts made by trade unions. The reason is that the introduction of health and safety measures, and in general the additional protection offered by unions, make workers feel safer. As a reaction, workers adapt their behaviour and reduce their own self-prevention activities, more than offsetting any injury-reducing effects intended by unions. The net impact is an increase in occupational injuries. In this section, I provide indirect and direct evidence for the moral hazard explanation.

4.5.1 Indirect evidence

The indirect evidence for the moral hazard explanation is based on the fact that some occupational health and safety measures that have been traditionally supported by trade unions have not always reduced occupational injuries as expected. For example, as it was mentioned in the introduction, it is well-known that one of the safety-enhancing activities of trade unions is to provide workers with protective equipment. Klen (1997), however, finds that the introduction of personal protectors (like safety helmets, eye protectors, or ear caps) did not reduce accident injuries among Finnish loggers as intended, partially because of moral hazard.

Another safety-enhancing union activity is to lobby and support the passage of government legislation and to monitor its enforcement. Trade unions, for example, were not only crucial in the passage of the Occupational Safety and Health Act (OHSA) in 1970, but the empirical evidence also suggests that the OHSA is better enforced in union establishments (Weil 1991, 1992). In spite of this, the impact of the OHSA on reducing occupational injuries has been labelled by many as ineffective (Viscusi 1986). Viscusi (1979b) argues that the reason for this might lie in the idea that safety regulations that increase enterprises' investment in work quality might be offset if workers react by diminishing their own safety-enhancing actions.

Yet another safety-enhancing activity of unions is to aid and represent workers in accident compensation claims. Borba and Appel (1987), for example, find that workers' compensation claimants who are union members are more likely to be represented by attorneys than are nonunion workers (see also Latta and Lewis 1974). Probably because of this and other types of support, unionized workers seem to be more successful in the compensation process. In fact, Hirsch et al. (1997), conclude in their empirical study that "[u]nion workers are far more likely than nonunion workers, other things equal, to receive benefits from workers' compensation [...]" (p. 233). Other empirical studies have confirmed the positive impact of unionization on workers' compensation claims and benefits (see, for example, Butler and Worrall 1983 and Chelius 1974, p. 729). However, a well-established result from the workers' compensation literature is the presence of moral hazard. In fact, the evidence from this literature shows that workers' compensation is encouraging *more*, not less, nonfatal injuries but seems to be reducing fatalities (Moore and Viscusi 1990, ch. 9, Ruser 1993). This is exactly the pattern found in Figure 4-2. In other words, unions might be facilitating a more extensive use of workers' compensation and thus, probably unwillingly, magnifying the moral hazard problems of this system.

4.5.2 Direct evidence

Within variation and union joiners-leavers analysis

Direct evidence for the moral hazard explanation can be found with panel data at the individual level. In fact, when only cross-sectional data is available, it is only possible to estimate the union impact on injuries by comparing the group of unionized with the group of nonunionized workers in one single period of time. However, in order to find evidence of moral hazard, we still need to establish if *the same* worker is having more injuries after joining a union. The question is if there is an increase in the injury probability of a worker that in period one was not unionized and in period two joins a union. Has joining a union made any difference for this worker in terms of injury probability? Or, in other words, is this worker adapting his safety behaviour after joining a union? This type of analysis can only be performed with panel data at the individual level, like the NLSY79, since only this type of data has information on the same person for two or more periods. None of the previous studies from the literature was able to perform such an analysis because of data limitations.

In this chapter, most regressions have been estimated by fixed effects, a panel-data estimation method. The fixed-effects estimator only relies on the so-called within variation, that is, the variation over time of a given individual (see fn. 10). As a consequence, the estimates presented so far already provide evidence of moral hazard since they imply that the injury probability of the same worker is increased when the worker changes status from nonunion to union.

However, in order to take this analysis to a deeper level, I extended the model in (4.1) to a less restrictive model that allows different changes in union status to have different impacts on the injury probability. The estimated model was

$$INJURY = \beta_{nu}NU + \beta_{uu}UU + \beta_{un}UN + \mathbf{X}'\boldsymbol{\gamma} + u, \tag{4.4}$$

where NU, UU, UN, and NN are two-period union status dummies (NN is the omitted category). In particular, NU is equal to one if the worker is not unionized in period $t-1$ and unionized in t; UU is equal to one if unionized in both periods; UN is equal to one if unionized in $t-1$ and not unionized in t; and NN is equal to one if not unionized in both periods. Thus, the coefficients β_{nu}, β_{uu}, and β_{un} respectively measure the relative difference in injury probabilities of union joiners (UN), union stayers (NN), and union leavers (NU) with respect to the omitted category of nonunion stayers (NN). This model is, therefore, less restrictive than (4.1) in the sense that β does not have to be symmetrical so that the estimates of union joiners and union leavers might differ, that is, β_{nu} might be different from β_{un}.

Since the proportion of workers who change their union status is in general relatively low, large data sets, like the NLSY79, with sufficient observations are needed to provide a meaningful analysis. Summary statistics of the union status dummies are relegated to the appendix (Table C.2). Simply note that on average there are 80.7% of nonunion stayers, 11.2% of union stayers, 3.7% of union joiners, and 4.4% of union leavers in the sample.

The union fixed-effects estimates of (4.4) and of an extended version of (4.4) with three-period union status dummies are presented in Table 4.9.[15] Columns (1) and (3) report the estimated coefficients of the union status dummies and the computed baselines. Adding these estimates to their respective baselines gives the injury probabilities reported in columns (2) and (4).

Let us now turn to the interpretation of these results. As can be seen from columns (1) and (3), not all estimates are significant. However, for the union status dummies the significance test is whether the coefficient is different from the omitted category of nonunion stayers (NN and NNN), and not whether the coefficient is different from zero. This means in column (1) that only UU is significantly different from NN and in column (3) that only NUU and UUU are significantly different from NNN. I argue here that these results are consistent with the moral hazard explanation. The interpretation is as follows: The injury probability of union joiners

[15] The methodology employed here has never been used before to study the impact of changes in union status on injury probabilities. This methodology was borrowed from the literature studying the impact of changes in union status on wages (see Lewis 1986, ch. 5, and the references therein).

Table 4.9: Fixed-effects estimates of the union status changes variables

	2 periods			3 periods	
	(1) Estimates	(2) Injury probability		(3) Estimates	(4) Injury probability
NU	0.006 (0.009)	6.6%	*NNU*	0.004 (0.010)	6.5%
UU	0.031 (0.009)***	9.1%	*NUU*	0.025 (0.013)*	8.6%
UN	-0.005 (0.007)	5.5%	*UUU*	0.025 (0.012)**	8.6%
			UUN	-0.013 (0.011)	4.9%
			UNN	-0.004 (0.007)	5.7%
NN baseline	0.060	6%	*NNN* baseline	0.061	6.1%
Controls?	Yes		Controls?	Yes	
Observations	41182		Observations	35527	

Notes: The table reports fixed-effects estimates of the coefficients of the union status dummies in equation (4.4) and in an extended version of equation (4.4) for three-period union status dummies. The union status dummies were created only using information on MEMBERSHIP (see notes from Table C.2 for details). The outcome variable is always NFI. All estimates are based on linear probability models and include the full set of control variables defined in Table C.1 plus 8 year dummies and the variables WAGE and INDUSTRYRISK. The less interesting variables *NUN* and *UNU* were also included in the three-period regression but their estimates are not reported in this table. The *NN* and *NNN* baselines are computed as the average predicted probability of the outcome variable using the estimated coefficients on the control variables. The injury probability is computed by adding the estimated coefficients to the baselines. Standard errors in parenthesis are cluster robust. *** p<0.01, ** p<0.05, * p<0.1.

(*NU* and *NNU*) is higher than that of nonunion stayers (*NN* and *NNN*) but the difference between the two is not significant (since *NU* and *NNU* are insignificant). Only after two periods of unionization the difference in probabilities is statistically different (since *UU* and *NUU* are significant). Note also that the probability after two periods of unionization is not statistically different to the probability after three periods of unionization ($NUU = UUU$).[16] These results suggest that it takes some time for workers to adapt to the new union safety and protection before they reduce their own precautionary levels. After two periods of unionization, however, workers seem to be fully adapted and their injury probability remains unchanged after reaching a significantly higher level. Additionally, the results also show that when the union protection is over, the moral hazard effect disappears. In fact, the probabilities after one or two periods since leaving the union (*UN*, *UUN* and *UNN*) are not statistically different to those of nonunion stayers (since *UN*, *UUN* and *UNN* are insignificant). This suggests that when a worker leaves a union, his injury probability immediately reaches the level as if he has never been unionized.

[16] The null hypothesis $NUU = UUU$ could not be rejected at any significance level below 97%.

Health and life insurance

In this subsection, I report the results of an experiment in which I compared the injury probability of "protected" with that of "unprotected" workers. In this sense, a worker that joins a union is more "protected" than a nonunion worker. Similarly, a worker that has a health and/or a life insurance is more "protected" than an uninsured worker. I provide here evidence that the most "protected" workers are those with the highest injury probabilities, giving more support to the moral hazard explanation.

Before presenting the results, first note that in the United States, workers who are injured in the course of employment receive benefits from their employer under the workers' compensation system. These benefits range from medical to total disability benefits for nonfatal injuries and extend to burial and survival benefits for fatal injuries. Parallel to the workers' compensation system, employers might provide workers with health or with life insurance covering for incidents not connected to the job.

Since health and life insurance do not cover for off-the-job incidents, there is in principle no reason why these types of insurance might have any impact on occupational injuries. However, there is some evidence that workers use health insurance to cover for occupational injuries (see Azaroff et al. 2002). In that sense, the injury probability of a worker might be influenced by having health and/or life insurance.

This hypothesis can be tested using the NLSY79 data set. There are in particular two questions asking respondents if employers made available to them health (HEALTHINS) or life insurance (LIFEINS) that covers injuries, illnesses or death off the job. The definitions and summary statistics of these variables are presented in Table 4.3. In the sample that I considered, around 76% of the respondents had an employer-provided health insurance and around 65% an employer-provided life insurance.

The fixed-effects estimates (not shown) of HEALTHINS and LIFEINS, including one of these variables at the time, in a regression such as (4.1) were all positive and highly significant, suggesting that insured workers have a higher injury probability. An even more interesting exercise can be performed by interacting the HEALTHINS and LIFEINS variables with the union status variables. In particular, it is possible to create dummies for every one of the four possible combinations between union worker (yes or no) and insured worker (yes or no). Following this, an equation such as (4.1) can be estimated but with the $UNION$ variable replaced by the dummies created and using the "no-union-no-insured" dummy as the base category. The injury probabilities that resulted from this exercise are reported in Table 4.10.

Table 4.10: Injury probabilities of union, nonunion, insured, and uninsured workers

		HEALTHINS		LIFEINS	
		no	yes	no	yes
COVERAGE	no	4.9%	6.6%	5.6%	6.4%
	yes	6.5%	7.8%	6.5%	8.0%
MEMBERSHIP	no	4.9%	6.6%	5.5%	6.5%
	yes	7.3%	8.2%	7.2%	8.2%

Notes: The table reports the injury probabilities of union, nonunion, insured, and uninsured workers that resulted from estimating a regression like (4.1) but replacing the *UNION* variable for interaction dummies between the insurance variables HEALTHINS and LIFEINS and the union status variables COVERAGE and MEMBERSHIP. The outcome variable of the original regression was NFI. All estimates were by fixed effects and were based on linear probability models that included the full set of control variables defined in Table C.1 plus 8 year dummies and the variables WAGE and INDUSTRYRISK.

It is clear from the table that, regardless of the union status variable or insurance type considered, the lowest injury probabilities are for the uninsured, nonunion workers. According to moral hazard, these are the workers that should perceive the highest risk and that should take the most safety precautions, leading to lower injury probabilities. In fact, as the table shows, providing workers with more "protection" in the form of either insurance or of union services increases their injury probability non-negligibly. Moreover, the highest injury probabilities are for the workers that have the highest "protection": the union and insured workers.

Another interesting result that reinforces this idea and that is not only apparent from Table 4.10 but from the estimates in Table 4.4 and the estimates that are not reported in this chapter is that union *members* exhibit higher injury probabilities than workers *covered* by a union contract. This gives further support to the moral hazard explanation since membership gives workers more protection than coverage.

4.6 Conclusions

This chapter begins by presenting a quantitative analysis based on 25 empirical studies investigating the impact of trade unions on occupational injuries. The analysis provides a very clear but paradoxical conclusion: Most empirical papers associate unions with *more* nonfatal occupational injuries. This result is very puzzling since it clearly contradicts expectations based on anecdotal evidence and on unions' safety-enhancing activities. Moreover, my own estimates using individual-level panel data for the first time confirm and reinforce this paradoxical result, indicating that union members are at least 29% more likely to have a nonfatal occupational injury than their nonunion counterparts.

The question is "why do unionized workers have more nonfatal occupational injuries?". The main goal of this chapter was to provide an answer to this question. I first looked in the literature for answers and found that three explanations were often suggested but there was almost no empirical evidence supporting or rejecting them. Using panel data from the National Longitudinal Survey of Youth 1979, I tried to produce empirical evidence for these explanations but the results were also very surprising: None of the three major explanations from the literature was supported by my results using standard econometric methods. This suggested to me that there was a substantial missing piece to the puzzle.

My results, however, pointed in a different direction and suggested that the paradox could be solved by applying the concept of moral hazard. In particular, moral hazard is able to explain why unionized workers are more likely to have a nonfatal occupational injury in spite of all unions' safety-enhancing activities. The reason is that when a worker joins a trade union, he enjoys an additional protection that reduces his risk exposure. As in traditional moral hazard applications, additional protection makes individuals reduce their own self-prevention activities and the outcome is often the opposite to the initial intentions. In this case, unions provide workers with a safer working environment. Workers react to this by reducing their own self-prevention efforts, more than offsetting the effects intended by unions. The result is more nonfatal occupational injuries for union workers. The anecdotal and empirical evidence presented in this chapter are very consistent with the moral hazard explanation.

Further research should overcome some of the limitations of this chapter. First of all, it should establish if the paradoxical relationship between unions and nonfatal injuries also extends to other countries not considered here. Second, more detailed data should be collected that allows to identify workers' moral hazard behaviour after the introduction of specific occupational health and safety measures. Finally, further research should establish why unions have not sufficiently considered the potential negative implications of moral hazard resulting from their safety-enhancing activities.

Appendix A

Appendix to Chapter 2

A.1 The first-order conditions for the general case

A.1.1 The welfare-maximizing safety level (s^U)

Setting to zero the derivative of $U(Y(s), z(s)) = U(Y(A(s), z(s)N), z(s))$ with respect to s yields

$$\begin{aligned}
U_s &= U_Y [Y_A A_s + Y_L z_s N] + U_z z_s = 0 \\
&\Leftrightarrow \ -U_Y Y_A A_s = [U_Y Y_L N + U_z] z_s \\
&\Leftrightarrow \ -\frac{U_Y}{U} Y_A A_s = \left[\frac{U_Y}{U} Y_L N \frac{z}{s} + \frac{U_z}{U}\frac{z}{s}\right] \frac{z_s s}{z} \\
&\Leftrightarrow \ -\frac{U_Y Y}{U}\frac{Y_A A}{Y}\frac{A_s s}{A} = \left[\frac{U_Y Y}{U}\frac{Y_L L}{Y} + \frac{U_z z}{U}\right] \frac{z_s s}{z}.
\end{aligned}$$

Using (2.9) finally gives $\varepsilon_{UY}\varepsilon_{YA}\varepsilon_{As} = [\varepsilon_{UY}\varepsilon_{YL} + \varepsilon_{Uz}]\,\varepsilon_{zs}$.

A.1.2 The output-maximizing safety level (s^Y)

Setting to zero the derivative of $Y(s) = Y(A(s), z(s)N)$ with respect to s yields

$$Y_s = Y_A A_s + Y_L z_s N = 0 \Longleftrightarrow -\frac{Y_A A}{Y}\frac{A_s s}{A} = \frac{Y_L L}{Y}\frac{z_s s}{z}.$$

Using (2.9) finally gives $\varepsilon_{YA}\varepsilon_{As} = \varepsilon_{YL}\varepsilon_{zs}$.

A.1.3 The trade union's maximization problem at the firm level (s^v)

The problem can be reformulated as $\max_s v = v\left(wl\left(A\left(s\right)\right), z\left(s\right)\right)$. The first-order condition is

$$v_s = v_{wl}wl_A A_s + v_z z_s = 0 \Longleftrightarrow -\frac{v_{wl}wl}{v}\frac{l_A A}{l}\frac{A_s s}{A} = \frac{v_z z}{v}\frac{z_s s}{z}.$$

Using (2.9) yields $\varepsilon_{vwl}\varepsilon_{lA}\varepsilon_{As} = \varepsilon_{vz}\varepsilon_{zs}$.

A.1.4 The trade union confederation's maximization problem (s^V)

The maximization problem is $\max_s V = V\left(w\left(A\left(s\right), z\left(s\right)N\right) \cdot z\left(s\right)N, z\left(s\right)\right)$. The first-order condition is

$$V_s = V_{wL}\left[\left[w_A A_s + w_L z_s N\right] zN + w z_s N\right] + V_z z_s = 0$$

$$\Longleftrightarrow -\frac{V_{wL}wL}{V}\frac{w_A A}{w}\frac{A_s s}{A} = \left[\frac{V_{wL}wL}{V}\left[1 + \frac{w_L L}{w}\right] + \frac{V_z z}{V}\right]\frac{z_s s}{z}.$$

Using (2.9) yields $\varepsilon_{VwL}\varepsilon_{wA}\varepsilon_{As} = \left[\varepsilon_{VwL}\left[1 - \varepsilon_{wL}\right] + \varepsilon_{Vz}\right]\varepsilon_{zs}$.

A.1.5 The capital holders' maximization problem at the country level (s^R)

Setting to zero the derivative of $r\left(s\right)K = r\left(A\left(s\right), z\left(s\right)N\right)K$ with respect to s yields

$$r_s K = \left[r_A A_s + r_L z_s N\right]K = 0 \Longleftrightarrow -\frac{r_A A}{r}\frac{A_s s}{A} = \frac{r_L L}{r}\frac{z_s s}{z}.$$

Using (2.9) finally gives $\varepsilon_{rA}\varepsilon_{As} = \varepsilon_{rL}\varepsilon_{zs}$.

A.2 Explicit elasticities and first-order conditions

The following elasticities are necessary in order to be able to compute the first-order conditions reported on table 2.1 on the main text.

A.2.1 The elasticities for the Cobb-Douglas production function

The elasticities are computed for the CD production function in (2.19) and (2.20).

- **TFP elasticities**

For the CD production function in (2.19), the first-order conditions are

$$w = Ak^{\alpha}\left[1-\alpha\right]l^{-\alpha} \Longleftrightarrow l = \left[\frac{A\left[1-\alpha\right]}{w}\right]^{\frac{1}{\alpha}}k, \tag{A.2}$$

$$r = A\alpha k^{\alpha-1} l^{1-\alpha} \Longleftrightarrow k = \left[\frac{A\alpha}{r}\right]^{\frac{1}{1-\alpha}} l. \tag{A.3}$$

The TFP elasticity of labour can be computed with (A.2) as

$$\varepsilon_{lA} \equiv l_A \frac{A}{l} = \frac{d\ln l}{d\ln A} = \frac{1}{\alpha}. \tag{A.4}$$

The TFP elasticity of capital computed with (A.3) is $\varepsilon_{kA} \equiv k_A \frac{A}{k} = \frac{1}{1-\alpha}$.

- **The labour elasticities**

The output elasticity of labour from (2.20) is $1-\alpha$. The labour elasticity of the wage is $\varepsilon_{wL} \equiv -w_L \frac{l}{w} = -\frac{d\ln w}{d\ln l} = \alpha$. The labour elasticity of the capital reward is $\varepsilon_{rL} \equiv r_L \frac{L}{r} = 1-\alpha$.

A.2.2 The elasticities for the CES utility functions

The elasticities are computed using (2.16), (2.17), and (2.18). To obtain the CD case, simply set $\lambda = 0$.

- **The elasticities for the central planner**

The output elasticity of welfare is

$$\begin{aligned} \varepsilon_{UY} &\equiv \frac{\partial U}{\partial Y}\frac{Y}{U} = \frac{1}{\lambda}\left\{\mu Y^{\lambda} + [1-\mu]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} \mu\lambda Y^{\lambda-1} \frac{Y}{\{\mu Y^{\lambda} + [1-\mu]\, z^{\lambda}\}^{\frac{1}{\lambda}}} \\ &= \frac{\mu Y^{\lambda}}{\mu Y^{\lambda} + [1-\mu]\, z^{\lambda}} = \frac{1}{1 + \frac{1-\mu}{\mu}\left[\frac{z}{Y}\right]^{\lambda}}. \end{aligned}$$

The health elasticity of welfare is

$$\begin{aligned} \varepsilon_{Uz} &\equiv \frac{\partial U}{\partial z}\frac{z}{U} = \left\{\mu Y^{\lambda} + [1-\mu]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} \frac{[1-\mu]\, z^{\lambda}}{z} \frac{z}{\{\mu Y^{\lambda} + [1-\mu]\, z^{\lambda}\}^{\frac{1}{\lambda}}} \\ &= \frac{[1-\mu]\, z^{\lambda}}{\mu Y^{\lambda} + [1-\mu]\, z^{\lambda}} = \frac{1}{1 + \frac{\mu}{1-\mu}\left[\frac{Y}{z}\right]^{\lambda}}. \end{aligned}$$

- **The elasticities for the firm-level trade union**

The labour income elasticity of utility is

$$\begin{aligned} \varepsilon_{vwl} &\equiv \frac{\partial v}{\partial wl}\frac{wl}{v} = \frac{1}{\lambda}\left\{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} \gamma\lambda\,[wl]^{\lambda-1} \frac{wl}{\left\{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}\right\}^{\frac{1}{\lambda}}} \\ &= \frac{\gamma\,[wl]^{\lambda}}{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}} = \frac{1}{1 + \frac{1-\gamma}{\gamma}\left[\frac{z}{wl}\right]^{\lambda}}. \end{aligned} \tag{A.5}$$

The health elasticity of utility is

$$\varepsilon_{vz} \equiv \frac{\partial v}{\partial z}\frac{z}{v} = \frac{1}{\lambda}\left\{\gamma\left[wl\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}\right\}^{\frac{1}{\lambda}-1}\left[1-\gamma\right]\lambda z^{\lambda-1}\frac{z}{\left\{\gamma\left[wl\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}\right\}^{\frac{1}{\lambda}}}$$

$$= \frac{\left[1-\gamma\right]z^{\lambda}}{\gamma\left[wl\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}} = \frac{1}{1+\frac{\gamma}{1-\gamma}\left[\frac{wl}{z}\right]^{\lambda}}. \tag{A.6}$$

- **The elasticities for the union confederation**

The labour income elasticity of utility is

$$\varepsilon_{VwL} \equiv \frac{\partial V}{\partial wL}\frac{wL}{V} = \frac{1}{\lambda}\left\{\gamma\left[wL\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}\right\}^{\frac{1}{\lambda}-1}\gamma\lambda\left[wL\right]^{\lambda-1}\frac{wL}{\left\{\gamma\left[wL\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}\right\}^{\frac{1}{\lambda}}}$$

$$= \frac{\gamma\left[wL\right]^{\lambda}}{\gamma\left[wL\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}} = \frac{1}{1+\frac{1-\gamma}{\gamma}\left[\frac{z}{wL}\right]^{\lambda}} = \frac{1}{1+\frac{1-\gamma}{\gamma}\left[\frac{z}{wzN}\right]^{\lambda}}.$$

The health elasticity of utility is

$$\varepsilon_{Vz} \equiv \frac{\partial V}{\partial z}\frac{z}{V} = \frac{1}{\lambda}\left\{\gamma\left[wL\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}\right\}^{\frac{1}{\lambda}-1}\left[1-\gamma\right]\lambda z^{\lambda-1}\frac{z}{\left\{\gamma\left[wL\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}\right\}^{\frac{1}{\lambda}}}$$

$$= \frac{\left[1-\gamma\right]z^{\lambda}}{\gamma\left[wL\right]^{\lambda} + \left[1-\gamma\right]z^{\lambda}} = \frac{1}{1+\frac{\gamma}{1-\gamma}\left[\frac{wL}{z}\right]^{\lambda}} = \frac{1}{1+\frac{\gamma}{1-\gamma}\left[\frac{wzN}{z}\right]^{\lambda}}.$$

A.2.3 The elasticities for the particular forms of A and z

The elasticities are computed using (2.21). The safety elasticity of TFP is

$$\varepsilon_{As} \equiv -\frac{\partial A}{\partial s}\frac{s}{A} = -\left[-\phi\right]be^{-\phi s}\frac{s}{be^{-\phi s}} = \phi s. \tag{A.7}$$

The safety elasticity of health is

$$\varepsilon_{zs} \equiv \frac{\partial z}{\partial s}\frac{s}{z} = -\left[-\chi\right]\bar{q}e^{-\chi s}\frac{s}{z} = \frac{1-z}{z}\chi s = \left[z\left(s\right)^{-1} - 1\right]\chi s. \tag{A.8}$$

A.2.4 The first-order conditions for the particular case

The safety levels for our particular functions can be easily computed by inserting the above elasticities in the general first-order conditions from app. A.1.

For example, the welfare-maximizing safety level s^U is described in (2.8) by the general first-order condition $\varepsilon_{UY}\varepsilon_{YA}\varepsilon_{As} = \left[\varepsilon_{UY}\varepsilon_{YL} + \varepsilon_{Uz}\right]\varepsilon_{zs}$. Inserting the elasticities from app. A.2 yields

$\varepsilon_{UY} \cdot 1 \cdot \phi s = [\varepsilon_{UY} [1-\alpha] + \varepsilon_{Uz}] \left[z(s)^{-1} - 1 \right] \chi s$. Plugging (2.21) and rearranging gives s

$$\begin{aligned}
\phi &= \left[1-\alpha+\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\left[\frac{1}{1-\bar{q}e^{-\chi s}}-1\right]\chi \Longleftrightarrow \phi = \left[1-\alpha+\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\left[\frac{\bar{q}e^{-\chi s}}{1-\bar{q}e^{-\chi s}}\right]\chi \\
&\Longleftrightarrow \phi\left[1-\bar{q}e^{-\chi s}\right] = \left[1-\alpha+\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\bar{q}e^{-\chi s}\chi \Longleftrightarrow \frac{\left[\left[1-\alpha+\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\chi+\phi\right]\bar{q}}{\phi} = e^{\chi s} \\
&\Longleftrightarrow \ln\left[\frac{\left[\left[1-\alpha+\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\chi+\phi\right]\bar{q}}{\phi}\right] = \chi s \\
&\Longleftrightarrow s^U = \chi^{-1}\ln\left[\left(1+\left[\frac{\varepsilon_{Uz}\left(s^U\right)}{\varepsilon_{UY}\left(s^U\right)}+1-\alpha\right]\frac{\chi}{\phi}\right)\bar{q}\right].
\end{aligned}$$

Other expressions can be derived in analogy.

A.3 OHS rankings

A.3.1 Rankings in the general case

Theorem 1 $s^Y < s^U$.

Proof. s^U is determined by $U_s = U_Y Y_s + U_z z_s = 0$ and s^Y by $Y_s = 0$ which is equivalent to $U_Y Y_s = 0$. Now, for our model to make sense at all, we need to assume $Y_s > 0$ and $Y_{ss} < 0$. In other words, since $U_Y > 0$, the function $U_Y Y_s$ falls monotonically in s until zero is reached and where $s = s^Y$. Moreover, since $U_z > 0$ and $z_s > 0$, then $U_z z_s > 0$. The theorem follows since adding a positive term to $U_Y Y_s$ implies that $s^Y < s^U$. ∎

A.3.2 Rankings in the Cobb-Douglas case

The following theorems allow us to compare the safety levels from table 2.1.

Theorem 2 $s^U \lesseqqgtr s^V \Longleftrightarrow \gamma \lesseqqgtr \mu$.

Proof. $s^V > s^U$

$$\begin{aligned}
&\Longleftrightarrow \chi^{-1}\ln\left[\left(1+\left(\frac{1-\gamma}{\gamma}+1-\alpha\right)\frac{\chi}{\phi}\right)\bar{q}\right] > \chi^{-1}\ln\left[\left(1+\left(\frac{1-\mu}{\mu}+1-\alpha\right)\frac{\chi}{\phi}\right)\bar{q}\right] \\
&\Longleftrightarrow \mu > \gamma.
\end{aligned}$$

The rest of the theorem can be proven in a similar fashion. ∎

Theorem 3 $s^V > s^v \Longleftrightarrow \alpha < 1$, $s^v \lesseqqgtr s^U \Longleftrightarrow \mu\alpha \lesseqqgtr \gamma$

Proof. Similar to the previous proof. ■

With these results, one can establish that $\alpha < \gamma < \mu$ implies ranking (2.22) used in the main text.

A.4 OHS and development

A.4.1 Capital and the welfare-maximizing safety level

Theorem 4

$$\left\{\begin{array}{c} 0<\lambda<1 \\ \lambda=0 \\ \lambda<0 \end{array}\right\} \Longrightarrow \frac{ds^U}{dK}\left\{\begin{array}{c} ? \\ = \\ > \end{array}\right\} 0.$$

Proof. The proof has two parts.

(i) Using our results from app. A.2.2, we can compute

$$\frac{\varepsilon_{Uz}}{\varepsilon_{UY}} = \frac{1-\mu}{\mu}\left[\frac{z\left(s^U\right)}{Y\left(s^U,K\right)}\right]^{\lambda}.$$

For the Cobb-Douglas production function, we can compute

$$\frac{z\left(s^U\right)}{Y\left(s^U,K\right)} = \frac{z\left(s^U\right)}{A\left(s^U\right)K^{\alpha}z\left(s^U\right)^{1-\alpha}N^{1-\alpha}} = \frac{z\left(s^U\right)^{\alpha}}{A\left(s^U\right)}\frac{1}{K^{\alpha}N^{1-\alpha}}.$$

Since $z_s > 0$ and $A_s < 0$, we can conclude that $\frac{\partial(z/Y)}{\partial s^U} > 0$ and $\frac{\partial(z/Y)}{\partial K} < 0$, so that

$$\frac{\partial\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}}{\partial K}\left\{\begin{array}{c} < \\ = \\ > \end{array}\right\} 0 \Longleftarrow \lambda\left\{\begin{array}{c} > \\ = \\ < \end{array}\right\} 0 \Longrightarrow \frac{\partial\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}}{\partial s^U}\left\{\begin{array}{c} > \\ = \\ < \end{array}\right\} 0. \tag{A.9}$$

(ii) Plugging some of the elasticities from app. A.2 into the general first-order condition giving s^U and after rearranging, we can define

$$M \equiv \phi - \left[1-\alpha+\frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\left(s^U,K\right)\right]\left[\frac{1}{z\left(s^U\right)}-1\right]\chi = 0.$$

With the aid of the implicit-function theorem, we can now compute

$$\frac{ds^U}{dK} = -\frac{\partial M/\partial K}{\partial M/\partial s^U}, \tag{A.10}$$

where

$$\frac{\partial M}{\partial K} = -\frac{\partial \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}}{\partial K}\left[\frac{1}{z} - 1\right]\chi,$$

and

$$\begin{aligned}\frac{\partial M}{\partial s^U} &= -\left[\frac{\partial \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}}{\partial s^U}\left[\frac{1}{z} - 1\right] + \left[1 - \alpha + \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right][-1]\, z^{-2} z_s\right]\chi \\ &= \left[\left[1 - \alpha + \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\frac{z_s}{z^2} - \frac{\partial \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}}{\partial s^U}\left[\frac{1}{z} - 1\right]\right]\chi.\end{aligned}$$

We can conclude with (A.9) that

$$\frac{\partial M}{\partial K}\left\{\begin{array}{c} > \\ = \\ < \end{array}\right\} 0 \Longleftarrow \lambda \left\{\begin{array}{c} > \\ = \\ < \end{array}\right\} 0 \Longrightarrow \frac{\partial M}{\partial s^U}\left\{\begin{array}{c} ? \\ > \\ > \end{array}\right\} 0. \tag{A.11}$$

The derivative $\partial M/\partial s^U$ is positive for $\lambda > 0$ only if

$$\left[\left[1 - \alpha + \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}\right]\frac{z_s}{z^2} - \frac{\partial \frac{\varepsilon_{Uz}}{\varepsilon_{UY}}}{\partial s^U}\left[\frac{1}{z} - 1\right]\right]\chi > 0.$$

The theorem follows from (A.10) and (A.11). ■

A.4.2 Capital and the union's safety level at the firm level

Theorem 5

$$\left\{\begin{array}{c} 0 < \lambda < 1 \\ \lambda = 0 \\ \lambda < 0 \end{array}\right\} \Longrightarrow \frac{ds^v}{dK}\left\{\begin{array}{c} ? \\ = \\ > \end{array}\right\}.$$

Proof. This proof is similar to that of Theorem 4. The proof has two parts.

(i) Using our results from app. A.2.2, we can compute

$$\frac{\varepsilon_{vz}}{\varepsilon_{vwl}} = \frac{1-\gamma}{\gamma}\left[\frac{z(s^v)}{wl(A(s^v))}\right]^{\lambda},$$

which after aggregation (we use here the symmetric equilibrium assumption and replace firm-level by aggregate variables) is given by

$$\frac{\varepsilon_{vz}}{\varepsilon_{vwl}} = \frac{1-\gamma}{\gamma}\left[\frac{z(s^v)}{w(K,s^v)\,L(A(s^v),K)}\right]^{\lambda}.$$

As on the aggregate level labour demand equals labour supply, we use $L\left(A\left(s^{v}\right), K\right)=z\left(s^{v}\right) N$. The wage rate that results from the Cobb-Douglas production function is

$$w\left(K, s^{v}\right)=A\left(s^{v}\right) K^{\alpha}[1-\alpha]\left[z\left(s^{v}\right) N\right]^{-\alpha}.$$

Total wage income is therefore

$$w L=[1-\alpha] A\left(s^{v}\right) K^{\alpha}\left[z\left(s^{v}\right) N\right]^{1-\alpha}=[1-\alpha] Y\left(s^{v}\right).$$

This allows us to compute

$$\frac{z\left(s^{v}\right)}{w\left(K, s^{v}\right) L\left(A\left(s^{v}\right), K\right)}=\frac{z\left(s^{v}\right)^{\alpha}}{A\left(s^{v}\right)} \frac{1}{[1-\alpha] K^{\alpha} N^{1-\alpha}}.$$

Since $z_{s}>0$ and $A_{s}<0$, we can conclude that $\frac{\partial z / w L}{\partial s^{v}}>0$ and $\frac{\partial z / w L}{\partial K}<0$, so that

$$\frac{\partial \frac{\varepsilon_{v z}}{\varepsilon_{v w l}}}{\partial K}\left\{\begin{array}{c}< \\ = \\ >\end{array}\right\} 0 \Longleftarrow \lambda\left\{\begin{array}{c}> \\ = \\ <\end{array}\right\} 0 \Longrightarrow \frac{\partial \frac{\varepsilon_{v z}}{\varepsilon_{v w l}}}{\partial s^{v}}\left\{\begin{array}{c}> \\ = \\ <\end{array}\right\} 0. \tag{A.12}$$

(ii) Plugging some of the elasticities from app. A.2 into the general first-order condition giving s^{v} and after rearranging, we can define

$$H \equiv \frac{\phi}{\alpha}-\frac{\varepsilon_{v z}}{\varepsilon_{v w l}}\left(s^{v}, K\right)\left[\frac{1}{z\left(s^{v}\right)}-1\right] \chi=0.$$

With the aid of the implicit-function theorem, we can now compute

$$\frac{d s^{v}}{d K}=-\frac{\partial H / \partial K}{\partial H / \partial s^{v}}, \tag{A.13}$$

where

$$\frac{\partial H}{\partial K}=-\frac{\partial \frac{\varepsilon_{v z}}{\varepsilon_{v w l}}}{\partial K}\left[\frac{1}{z\left(s^{v}\right)}-1\right] \chi,$$

and

$$\begin{aligned}
\frac{\partial H}{\partial s^{v}} & =-\left[\frac{\partial \frac{\varepsilon_{v z}}{\varepsilon_{v w l}}}{\partial s^{v}}\left[\frac{1}{z}-1\right]+\frac{\varepsilon_{v z}}{\varepsilon_{v w l}} \frac{-1}{z^{2}} z_{s}\right] \chi \\
& =\left[\frac{\varepsilon_{v z}}{\varepsilon_{v w l}} \frac{z_{s}}{z^{2}}-\frac{\partial \frac{\varepsilon_{v z}}{\varepsilon_{v w l}}}{\partial s^{v}}\left[\frac{1}{z}-1\right]\right] \chi.
\end{aligned}$$

We can conclude with (A.12) that

$$\frac{\partial H}{\partial K}\left\{\begin{array}{c}>\\=\\<\end{array}\right\}0\Longleftarrow\lambda\left\{\begin{array}{c}>\\=\\<\end{array}\right\}0\Longrightarrow\frac{\partial H}{\partial s^{v}}\left\{\begin{array}{c}?\\>\\>\end{array}\right\}0. \tag{A.14}$$

The derivative $\partial H/\partial s^{v}$ is positive for $\lambda>0$ only if

$$\left[\frac{\varepsilon_{vz}}{\varepsilon_{vwl}}\frac{z_{s}}{z^{2}}-\frac{\partial\frac{\varepsilon_{vz}}{\varepsilon_{vwl}}}{\partial s^{v}}\left[\frac{1}{z}-1\right]\right]\chi>0.$$

The theorem follows from (A.13) and (A.14). ■

A.4.3 Capital and the union confederation's safety level

Theorem 6

$$\left\{\begin{array}{c}0<\lambda<1\\ \lambda=0\\ \lambda<0\end{array}\right\}\Longrightarrow\frac{ds^{V}}{dK}\left\{\begin{array}{c}?\\=\\>\end{array}\right\}.$$

Proof. This proof is similar to that of Theorem 4. The proof has two parts.

(i) Using our results from app. A.2.2, we can compute

$$\frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}=\frac{1-\gamma}{\gamma}\left[\frac{z\left(s^{V}\right)}{w\left(s^{V}\right)z\left(s^{V}\right)N}\right]^{\lambda}.$$

For the Cobb-Douglas production function, we can compute

$$\frac{z\left(s^{V}\right)}{w\left(s^{V}\right)z\left(s^{V}\right)N}=\frac{1}{A\left(s^{V}\right)K^{\alpha}\left[1-\alpha\right]z\left(s^{V}\right)^{-\alpha}N^{-\alpha}\cdot N}=\frac{z\left(s^{V}\right)^{\alpha}}{A\left(s^{V}\right)}\frac{1}{K^{\alpha}\left[1-\alpha\right]N^{1-\alpha}}.$$

Since $z_{s}>0$ and $A_{s}<0$, we can conclude that $\frac{\partial z/wzN}{\partial s^{V}}>0$ and $\frac{\partial z/wzN}{\partial K}<0$, so that

$$\frac{\partial\frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}}{\partial K}\left\{\begin{array}{c}<\\=\\>\end{array}\right\}0\Longleftarrow\lambda\left\{\begin{array}{c}>\\=\\<\end{array}\right\}0\Longrightarrow\frac{\partial\frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}}{\partial s^{V}}\left\{\begin{array}{c}>\\=\\<\end{array}\right\}0. \tag{A.15}$$

(ii) Plugging some of the elasticities from app. A.2 into the general first-order condition giving s^{V} and after rearranging, we can define

$$P\equiv\phi-\left[1-\alpha+\frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}\left(s^{V},K\right)\right]\left[\frac{1}{z\left(s^{V}\right)}-1\right]\chi=0.$$

With the aid of the implicit-function theorem, we can now compute

$$\frac{ds^V}{dK} = -\frac{\partial P/\partial K}{\partial P/\partial s^V}, \tag{A.16}$$

where

$$\frac{\partial P}{\partial K} = -\frac{\partial \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}}{\partial K}\left[\frac{1}{z\left(s^V\right)} - 1\right]\chi$$

and

$$\begin{aligned}\frac{\partial P}{\partial s^V} &= -\left[\frac{\partial \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}}{\partial s^V}\left[\frac{1}{z} - 1\right] + \left[1 - \alpha + \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}\right]\frac{-1}{z^2}z_s\right]\chi \\ &= \left[\left[1 - \alpha + \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}\right]\frac{z_s}{z^2} - \frac{\partial \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}}{\partial s^V}\left[\frac{1}{z} - 1\right]\right]\chi.\end{aligned}$$

We can conclude with (A.15) that

$$\frac{\partial P}{\partial K}\left\{\begin{array}{c} > \\ = \\ < \end{array}\right\} 0 \Longleftarrow \lambda \left\{\begin{array}{c} > \\ = \\ < \end{array}\right\} 0 \Longrightarrow \frac{\partial P}{\partial s^V}\left\{\begin{array}{c} ? \\ > \\ > \end{array}\right\} 0. \tag{A.17}$$

The derivative $\partial P/\partial s^V$ is positive for $\lambda > 0$ only if

$$\left[\left[1 - \alpha + \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}\right]\frac{z_s}{z^2} - \frac{\partial \frac{\varepsilon_{Vz}}{\varepsilon_{VwL}}}{\partial s^V}\left[\frac{1}{z} - 1\right]\right]\chi > 0.$$

The theorem follows from (A.16) and (A.17). ■

Appendix B

Appendix to Chapter 3

B.1 The central planner's optimality conditions in a two-country world

B.1.1 The consumption-maximizing safety level (s^C)

Consumption in the North is given by

$$C(s) = Y(A(s), K - \Delta(A(s), z(s)N), z(s)N) + r^*(A(s), z(s)N)\Delta(A(s), z(s)N). \quad \text{(B.1)}$$

Setting to zero the derivative of this with respect to s yields

$$C_s = Y_A A_s + Y_\Delta [\Delta_A A_s + \Delta_L z_s N] + Y_L z_s N + [r^*_A A_s + r^*_L z_s N]\Delta + r^* [\Delta_A A_s + \Delta_L z_s N] = 0.$$

Plugging $-Y_\Delta = r$ and rearranging yields

$$C_s = Y_A A_s + [r^* - r][\Delta_A A_s + \Delta_L z_s N] + Y_L z_s N + [r^*_A A_s + r^*_L z_s N]\Delta = 0.$$

In equilibrium $r^* = r = \tilde{r}$, so that

$$C_s = Y_A A_s + Y_L z_s N + [\tilde{r}_A A_s + \tilde{r}_L z_s N]\Delta = 0. \quad \text{(B.2)}$$

Multiplying all terms by $s\frac{Y}{Y}\frac{A}{A}\frac{z}{z}\frac{\Delta}{\Delta}\frac{\tilde{r}}{\tilde{r}}$ and rearranging yields

$$-Y_A \frac{A}{Y} A_s \frac{s}{A} - \tilde{r}_A \frac{A}{r^S} A_s \frac{s}{A}\frac{\tilde{r}\Delta}{Y} = Y_L \frac{zN}{Y} z_s \frac{s}{z} + \tilde{r}_L \frac{zN}{r^S} z_s \frac{s}{z}\frac{\tilde{r}\Delta}{Y}.$$

Plugging in the definitions of the elasticities from (3.5) finally yields

$$\left[\varepsilon_{YA} + \varepsilon_{\tilde{r}A}\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{As} = \left[\varepsilon_{YL} + \varepsilon_{\tilde{r}L}\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{zs}.$$

B.1.2 The welfare-maximizing safety level (s^U)

Welfare in the North is given by $U\left(C\left(s\right), z\left(s\right)\right)$, where consumption is (B.1). Setting to zero the derivative of this with respect to s yields

$$U_s = U_C C_s + U_z z_s = 0.$$

Plugging (B.2) and rearranging gives

$$U_C\left[Y_A A_s + Y_L z_s N + \left[\tilde{r}_A A_s + \tilde{r}_L z_s N\right]\Delta\right] + U_z z_s = 0.$$

Multiplying all terms by $\frac{C}{U}\frac{Y}{Y}\frac{A}{A}\frac{z}{z}\frac{\Delta}{\Delta}\frac{\tilde{r}}{\tilde{r}}s$ and rearranging gives

$$-U_C\frac{C}{U}\left[Y_A\frac{A}{Y}A_s\frac{s}{A}Y + \tilde{r}_A\frac{A}{r^S}A_s\frac{s}{A}\tilde{r}\Delta\right] = \left[U_C\frac{C}{U}Y_L\frac{zN}{Y}Y + U_C\frac{C}{U}\tilde{r}_L\frac{zN}{\tilde{r}}\tilde{r}\Delta + U_z\frac{z}{U}C\right]z_s\frac{s}{z}.$$

Plugging $C = Y + \tilde{r}\Delta$ and rearranging yields

$$-U_C\frac{C}{U}\left[Y_A\frac{A}{Y}A_s\frac{s}{A} + \tilde{r}_A\frac{A}{r^S}A_s\frac{s}{A}\frac{\tilde{r}\Delta}{Y}\right] = \left[U_C\frac{C}{U}Y_L\frac{zN}{Y} + U_z\frac{z}{U} + \left[U_C\frac{C}{U}\tilde{r}_L\frac{zN}{\tilde{r}} + U_z\frac{z}{U}\right]\frac{\tilde{r}\Delta}{Y}\right]z_s\frac{s}{z}.$$

Using the definitions of the elasticities from (3.5) finally yields

$$\varepsilon_{UC}\left[\varepsilon_{YA} + \varepsilon_{\tilde{r}A}\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{As} = \left[\varepsilon_{UC}\varepsilon_{YL} + \varepsilon_{Uz} + \left[\varepsilon_{UC}\varepsilon_{\tilde{r}L} + \varepsilon_{Uz}\right]\frac{\tilde{r}\Delta}{Y}\right]\varepsilon_{zs}.$$

B.1.3 The union's safety level (s^v)

The union maximizes (3.4) taking the wage as given, i.e. $\max_s v = v\left(wl\left(A\left(s\right)\right), z\left(s\right)\right).$ The first-order condition is

$$v_s = v_{wl} w l_A A_s + v_z z_s = 0 \Leftrightarrow -\frac{v_{wl}wl}{v}\frac{l_A A}{l}\frac{A_s s}{A} = \frac{v_z z}{v}\frac{z_s s}{z}.$$

Using (3.5) yields $\varepsilon_{vwl}\varepsilon_{lA}\varepsilon_{As} = \varepsilon_{vz}\varepsilon_{zs}$ which is (OCc) in tab. 3.1.

B.1.4 The interest-rate-maximizing safety level (s^R)

There are two approaches to computing the interest-rate-maximizing safety level. The key difference between these two approaches is when the equilibrium condition $r^* = r$ is used in the computation. One can insert this condition either after computing the first-order condition (approach 1) or right away after defining the objective function (approach 2). We will show that these two approaches lead to the same first-order condition, but that the second is faster.

- Approach 1: Using $r^* = r$ after first-order condition

Capital income in the North is given, using (3.6) and taking $\Delta(s) = \Delta(A(s), z(s) N)$ from (3.7) into account, by

$$r(s, \Delta(s))[K - \Delta(s)] + r^*(\Delta(s))\Delta(s). \tag{B.3}$$

When we compute the derivative with respect to s and set this to zero we obtain

$$\left[\frac{d}{ds} r(s, \Delta(s))\right][K - \Delta(s)] - r(s, \Delta(s))\Delta_s + \left[\frac{d}{ds} r^*(\Delta(s))\right]\Delta(s) + r^*(\Delta(s))\Delta_s = 0.$$

Plugging the equilibrium condition $r = r^* = \tilde{r}$ yields

$$\left[\frac{d}{ds} r(s, \Delta(s))\right][K - \Delta(s)] + \left[\frac{d}{ds} r^*(\Delta(s))\right]\Delta(s) = 0.$$

As in equilibrium the interest rates are the same, so must be their derivatives. Hence,

$$\left[\frac{d}{ds}\tilde{r}(s)\right] K = 0. \tag{B.4}$$

- Approach 2: Using $r^* = r$ after objective function

Capital income in the North is still given by (B.3). Plugging the equilibrium condition $r = r^* = \tilde{r}$ yields

$$\tilde{r}(s) K.$$

Computing the derivative of this expression with respect to s and setting it equal to zero yields

$$\left[\frac{d}{ds}\tilde{r}(s)\right] K = 0,$$

which is the same as (B.4).

- Rearranging the first-order condition

Since $\tilde{r}(s) = \tilde{r}(A(s), z(s)N)$, the first-order condition (B.4) can be expressed as

$$\tilde{r}_A A_s + \tilde{r}_L z_s N = 0.$$

Multiplying all terms by $\frac{A}{A}\frac{z}{z}\frac{\tilde{r}}{\tilde{r}}s$ and rearranging gives

$$-\tilde{r}_A \frac{A}{\tilde{r}} A_s \frac{s}{A} = \tilde{r}_L \frac{zN}{\tilde{r}} z_s \frac{s}{z}.$$

Using the definitions of the elasticities from (3.5) again finally yields the first-order condition

$$\varepsilon_{\tilde{r}A}\varepsilon_{As} = \varepsilon_{\tilde{r}L}\varepsilon_{zs}.$$

B.2 Explicit elasticities

The following elasticities are necessary in order to compute the first-order conditions reported in tab. 3.1 in the main text. The elasticities derived in this section are to some extent the same computations as in appendix A but are replicated here for convenience.

B.2.1 The elasticities for the Cobb-Douglas production function

The elasticities here are computed assuming a Cobb-Douglas production function

$$y = A(s) k^{\alpha} l^{1-\alpha}$$

at the firm level and

$$Y = A[K - \Delta]^{\alpha} [zN]^{1-\alpha} \qquad \text{and} \qquad Y^* = A^* [K^* + \Delta]^{\alpha} [z^* N^*]^{1-\alpha}$$

at the aggregate level.

- **TFP elasticity of labour**

The firm first-order condition with respect to l is

$$w = Ak^{\alpha}[1-\alpha] l^{-\alpha} \Leftrightarrow l = \left[\frac{A[1-\alpha]}{w}\right]^{\frac{1}{\alpha}} k$$

which can be used to compute the TFP elasticity of labour

$$\varepsilon_{lA} \equiv l_A \frac{A}{l} = \frac{d \ln l}{d \ln A} = \frac{1}{\alpha}.$$

- **Elasticities based on the world interest rate**

In order to compute the elasticities ε_{rA} and ε_{rL} we first need an expression for Δ and for r. For a Cobb-Douglas production function Δ is given by

$$r = r^* \Leftrightarrow A\alpha \left[K - \Delta\right]^{\alpha-1} \left[zN\right]^{1-\alpha} = A^*\alpha \left[K^* + \Delta\right]^{\alpha-1} \left[z^*N^*\right]^{1-\alpha}$$

$$\Leftrightarrow \Delta = \frac{\left[\frac{A^*}{A}\right]^{\frac{1}{1-\alpha}} \frac{z^*N^*}{zN} K - K^*}{1 + \left[\frac{A^*}{A}\right]^{\frac{1}{1-\alpha}} \frac{z^*N^*}{zN}}.$$

Plugging this in r or in r^* and rearranging gives the world interest rate

$$\tilde{r} = \alpha \left[\frac{\left[A^*\right]^{\frac{1}{1-\alpha}} z^*N^* + A^{\frac{1}{1-\alpha}} zN}{K + K^*}\right]^{1-\alpha}.$$

The TFP elasticity of the world interest rate is

$$\begin{aligned}
\varepsilon_{\tilde{r}A} &= \tilde{r}_A \frac{A}{\tilde{r}} = \alpha \left[1-\alpha\right] \left[\frac{\left[A^*\right]^{\frac{1}{1-\alpha}} z^*N^* + A^{\frac{1}{1-\alpha}} zN}{K + K^*}\right]^{-\alpha} \frac{\frac{1}{1-\alpha} A^{\frac{1}{1-\alpha}-1} zN}{K + K^*} \frac{A}{\alpha \left[\frac{\left[A^*\right]^{\frac{1}{1-\alpha}} z^*N^* + A^{\frac{1}{1-\alpha}} zN}{K+K^*}\right]^{1-\alpha}} \\
&= \frac{1}{1 + \left[\frac{A^*}{A}\right]^{\frac{1}{1-\alpha}} \frac{z^*N^*}{zN}}.
\end{aligned}$$

The labour elasticity of the world interest rate is

$$\begin{aligned}
\varepsilon_{\tilde{r}L} &= \tilde{r}_L \frac{L}{\tilde{r}} = \alpha \left[1-\alpha\right] \left[\frac{\left[A^*\right]^{\frac{1}{1-\alpha}} z^*N^* + A^{\frac{1}{1-\alpha}} L}{K + K^*}\right]^{-\alpha} \frac{A^{\frac{1}{1-\alpha}}}{K + K^*} \frac{L}{\alpha \left[\frac{\left[A^*\right]^{\frac{1}{1-\alpha}} z^*N^* + A^{\frac{1}{1-\alpha}} L}{K+K^*}\right]^{1-\alpha}} \\
&= \left[1-\alpha\right] \frac{1}{1 + \left[\frac{A^*}{A}\right]^{\frac{1}{1-\alpha}} \frac{z^*N^*}{zN}}.
\end{aligned}$$

B.2.2 The elasticities for the CES utility functions

The elasticities here are computed assuming CES utility functions

$$v = \left\{\gamma \left[wl\right]^{\lambda} + \left[1-\gamma\right] z \left(s\right)^{\lambda}\right\}^{1/\lambda}$$

for the trade union and

$$U = \left\{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}\right\}^{\frac{1}{\lambda}}$$

for the central planner.

- **The elasticities for the central planner**

The output elasticity of welfare is

$$\begin{aligned}
\varepsilon_{UC} &\equiv \frac{\partial U}{\partial C}\frac{C}{U} = \frac{1}{\lambda}\left\{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} \mu\lambda C^{\lambda-1} \frac{C}{\{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}\}^{\frac{1}{\lambda}}} \\
&= \frac{\mu C^{\lambda}}{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}} = \frac{1}{1 + \frac{1-\mu}{\mu}\left[\frac{z}{C}\right]^{\lambda}}.
\end{aligned}$$

The health elasticity of welfare is

$$\begin{aligned}
\varepsilon_{Uz} &\equiv \frac{\partial U}{\partial z}\frac{z}{U} = \left\{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} \frac{[1-\mu]\, z^{\lambda}}{z} \frac{z}{\{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}\}^{\frac{1}{\lambda}}} \\
&= \frac{[1-\mu]\, z^{\lambda}}{\mu C^{\lambda} + [1-\mu]\, z^{\lambda}} = \frac{1}{1 + \frac{\mu}{1-\mu}\left[\frac{C}{z}\right]^{\lambda}}.
\end{aligned}$$

- **The elasticities for the firm-level trade union**

The labour income elasticity of utility is

$$\begin{aligned}
\varepsilon_{vwl} &\equiv \frac{\partial v}{\partial wl}\frac{wl}{v} = \frac{1}{\lambda}\left\{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} \gamma\lambda\,[wl]^{\lambda-1} \frac{wl}{\left\{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}\right\}^{\frac{1}{\lambda}}} \\
&= \frac{\gamma\,[wl]^{\lambda}}{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}} = \frac{1}{1 + \frac{1-\gamma}{\gamma}\left[\frac{z}{wl}\right]^{\lambda}}.
\end{aligned}$$

The health elasticity of utility is

$$\begin{aligned}
\varepsilon_{vz} &\equiv \frac{\partial v}{\partial z}\frac{z}{v} = \frac{1}{\lambda}\left\{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}\right\}^{\frac{1}{\lambda}-1} [1-\gamma]\,\lambda z^{\lambda-1} \frac{z}{\left\{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}\right\}^{\frac{1}{\lambda}}} \\
&= \frac{[1-\gamma]\, z^{\lambda}}{\gamma\,[wl]^{\lambda} + [1-\gamma]\, z^{\lambda}} = \frac{1}{1 + \frac{\gamma}{1-\gamma}\left[\frac{wl}{z}\right]^{\lambda}}.
\end{aligned}$$

B.2.3 The elasticities for the particular forms of A and z

The elasticities here are computed using the particular forms

$$A(s) = be^{-\phi s}, \qquad z(s) = 1 - qe^{-\chi s}.$$

The safety elasticity of TFP is

$$\varepsilon_{As} \equiv -\frac{\partial A}{\partial s}\frac{s}{A} = -\left[-\phi\right] be^{-\phi s}\frac{s}{be^{-\phi s}} = \phi s.$$

The safety elasticity of health is

$$\varepsilon_{zs} \equiv \frac{\partial z}{\partial s}\frac{s}{z} = -\left[-\chi\right] qe^{-\chi s}\frac{s}{z} = \frac{1-z}{z}\chi s = \left[z\left(s\right)^{-1} - 1\right]\chi s.$$

B.3 Welfare implications

B.3.1 Capital flows and welfare

- **Impact on the North**

The derivative of the northern welfare function with respect to Δ is $\frac{dU}{d\Delta} = U_C\frac{\partial C}{\partial \Delta} + U_z z_s \frac{\partial s}{\partial \Delta}$, where

$$\frac{\partial C}{\partial \Delta} = Y_A A_s \frac{\partial s}{\partial \Delta} + Y_\Delta + Y_L z_s \frac{\partial s}{\partial \Delta} N + r^*_\Delta \Delta + r^*.$$

Plugging $-Y_\Delta = r$ and rearranging gives

$$\begin{aligned}\frac{dU}{d\Delta} &= U_C\left[r^* - r + r^*_\Delta \Delta\right] + U_C\left[Y_A A_s + Y_L z_s N\right]\frac{\partial s}{\partial \Delta} + U_z z_s \frac{\partial s}{\partial \Delta} \\ &= U_C\left[r^* - r + r^*_\Delta \Delta\right] + U_C Y_s \frac{\partial s}{\partial \Delta} + U_z z_s \frac{\partial s}{\partial \Delta},\end{aligned}$$

where in the last step we used $Y_s = Y_A A_s + Y_L z_s N$.

- **Impact on the South**

The derivative of the southern welfare function with respect to Δ is

$$\frac{dU^*}{d\Delta} = U^*_{C^*}\left[Y^*_\Delta - r^*_\Delta \Delta - r^*\right] = -U^*_{C^*} r^*_\Delta \Delta > 0,$$

since $Y^*_\Delta = r^*$. Notice that the derivative is positive since $r^*_\Delta < 0$.

B.3.2 Global unions and welfare

- **Impact on the North**

The northern welfare is given by $U = U\left(C\left(s^*\right), z\left(s\left(s^*\right)\right)\right)$, where

$$C\left(s^*\right) = Y\left(A\left(s\left(s^*\right)\right), K - \Delta\left(s^*\right), z\left(s\left(s^*\right)\right)N\right) + r^*\left(A^*\left(s^*\right), K^* + \Delta\left(s^*\right), z^*\left(s^*\right)N^*\right)\Delta\left(s^*\right).$$

We now compute $\frac{dU}{ds^*} = U_C \frac{\partial C}{\partial s^*} + U_z z_s \frac{\partial s}{\partial s^*}$, where

$$\frac{\partial C}{\partial s^*} = Y_A A_s \frac{\partial s}{\partial s^*} + Y_\Delta \frac{\partial \Delta}{\partial s^*} + Y_L z_s N \frac{\partial s}{\partial s^*} + r^*_{s^*} \Delta + r^* \frac{\partial \Delta}{\partial s^*}.$$

Plugging $-Y_\Delta = r$ and rearranging gives

$$\begin{aligned} \frac{dU}{ds^*} &= U_C \left[Y_A A_s \frac{\partial s}{\partial s^*} - r \frac{\partial \Delta}{\partial s^*} + Y_L z_s N \frac{\partial s}{\partial s^*} + r^*_{s^*} \Delta + r^* \frac{\partial \Delta}{\partial s^*} \right] + U_z z_s \frac{\partial s}{\partial s^*} \\ &= U_C r^*_{s^*} \Delta + U_C Y_s \frac{\partial s}{\partial s^*} + U_z z_s \frac{\partial s}{\partial s^*}, \end{aligned}$$

where in the last step we used $r^* = r$ and $Y_s = Y_A A_s + Y_L z_s N$.

- **Impact on the South**

The southern welfare function is given by $U^* = U^* \left(C^* \left(s^* \right), z^* \left(s^* \right) \right)$, where

$$C^* \left(s^* \right) = Y^* \left(A^* \left(s^* \right), K^* + \Delta \left(s^* \right), z^* \left(s^* \right) N^* \right) - r^* \left(A^* \left(s^* \right), K^* + \Delta \left(s^* \right), z^* \left(s^* \right) N^* \right) \Delta \left(s^* \right).$$

We now compute $\frac{dU^*}{ds^*} = U^*_{C^*} \frac{\partial C^*}{\partial s^*} + U^*_{z^*} z^*_{s^*}$, where

$$\frac{\partial C^*}{\partial s^*} = Y^*_{A^*} A^*_{s^*} + Y^*_\Delta \frac{\partial \Delta}{\partial s^*} + Y^*_{L^*} z^*_{s^*} N^* - r^*_{s^*} \Delta - r^* \frac{\partial \Delta}{\partial s^*}.$$

Plugging $Y^*_\Delta = r^*$ and rearranging gives

$$\begin{aligned} \frac{dU^*}{ds^*} &= U^*_{C^*} \left[Y^*_{A^*} A^*_{s^*} + Y^*_{L^*} z^*_{s^*} N^* - r^*_{s^*} \Delta \right] + U^*_{z^*} z^*_{s^*} \\ &= -U^*_{C^*} r^*_{s^*} \Delta + U^*_{C^*} Y^*_{s^*} + U^*_{z^*} z^*_{s^*}, \end{aligned}$$

where in the last step we used $Y^*_{s^*} = Y^*_{A^*} A^*_{s^*} + Y^*_{L^*} z^*_{s^*} N^*$.

Appendix C

Appendix to Chapter 4

Table C.1: Definitions and summary statistics of the control variables

Variable	Definition	Mean	Std. Dev.	Min	Max
HEALTH	1 if health limits kind of work	0.047	0.212	0	1
SATISF	Global job satisfaction on a scale of 1 to 4 (highest)	3.325	0.724	1	4
TENURE	Total tenure in weeks with employer	210.7	221.6	1	1588
TENURESQ	Square of TENURE	93491	176685	1	1588^2
FIRMSIZE	Log of nbr of employees at location of respondent's job	3.840	2.352	0	11.51
HOURSWEEK	Hours per week worked	40.17	11.87	0	168
EDUCATION	Highest grade completed	12.91	2.453	0	20
CHILDREN	Nbr of biological, adopted, or step-children in household	1.454	1.347	0	10
AGE	Age in years	31.95	4.389	23	44
MARRIED	1 if married	0.536	0.499	0	1
URBAN	1 if residence located in urban area	0.783	0.413	0	1
SOUTH*	1 if region of residence South	0.395	0.489	0	1
NORTHEAST	1 if region of residence Northeast	0.171	0.376	0	1
NORTHCENT	1 if region of residence North Central	0.234	0.423	0	1
WEST	1 if region of residence West	0.200	0.400	0	1
AGRICU	Agriculture, forestry, and fisheries	0.025	0.158	0	1
MINING	Mining	0.006	0.076	0	1
CONSTRUC	Construction	0.075	0.263	0	1
MANUF	Manufacturing	0.181	0.385	0	1
TRANSP	Transportation, communications, and other public utilities	0.068	0.252	0	1
TRADE	Wholesale and retail trade	0.176	0.380	0	1
FINANCE	Finance, insurance, and real estate	0.060	0.238	0	1
BUSINESS*	Business and repair services	0.080	0.271	0	1
PERSONAL	Personal services	0.045	0.208	0	1
ENTERTAIN	Entertainment and recreation services	0.014	0.118	0	1
PROFSERV	Professional and related services	0.206	0.405	0	1
PUBLIC	Public administration	0.060	0.238	0	1
PROFTECH	Professional, technical and kindred workers	0.171	0.376	0	1
MANAGER	Managers and administrators, except farm	0.124	0.330	0	1
SALES	Sales workers	0.044	0.204	0	1
CLERICAL*	Clerical and unskilled workers	0.180	0.384	0	1
CRAFT	Craftsmen and kindred workers	0.115	0.319	0	1
OPERAT	Operatives, except transport	0.093	0.291	0	1
TROPERAT	Transport equipment operatives	0.041	0.198	0	1
LABORERS	Laborers, except farm	0.063	0.243	0	1
FARMER	Farmers and farm managers	0.003	0.057	0	1
FARMLAB	Farm laborers and foreman	0.007	0.085	0	1
SERVICE	Service workers, except private household	0.148	0.355	0	1
PRIVATE	Private household workers	0.009	0.094	0	1

Notes: Statistics are for the years 88, 89, 90, 92, 93, 94, 96, 98, and 2000. Only variables for what the NLSY79 calls the "CPS job" or "job # 1" were used. The industry and occupation dummies are based on the classification system of the 1970 Census of Population. The asterisk denotes variables that were used as base category in the regressions.

Table C.2: Summary statistics of the union status dummies

Variable	Mean	Std. Dev.	Variable	Mean	Std. Dev.	Variable	Mean	Std. Dev.
NN	0.807	0.395	NNN	0.762	0.426	UNN	0.040	0.195
NU	0.037	0.188	NNU	0.028	0.164	UNU	0.009	0.095
UU	0.112	0.316	NUN	0.025	0.157	UUN	0.019	0.138
UN	0.044	0.204	NUU	0.022	0.148	UUU	0.094	0.292

Notes: The definition of the two-period union status dummies is given after equation (4.4). For the three-period union status dummies the definition is analogous. In order to maximize the number of observations, the union status dummies were constructed also using information on MEMBERSHIP from the years 1986 (for the three-period dummies) and 1987. The year 1991 was excluded from the analysis since there is no information on injuries for this year. In 1986 and 1987 only the question on COVERAGE was asked. Therefore, only for those two years, it was assumed that MEMBERSHIP=COVERAGE.

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