When safety science meets the practitioners:

Does safety science contribute to marginalization of practical knowledge?

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Abstract

In this paper we explore the proposal that knowledge generated by safety scientists may displace or marginalize existing local or system-specific safety knowledge embedded in operational practices. The proposition is based on theory about relationships between knowledge and power, complemented by organizational theory on standardization and accountability. We suggest that the increased reliance on self-regulation and international standards in safety management may be drivers for a shift in the distribution of power regarding safety, changing the conception of what is valid and useful knowledge. Case studies from two Norwegian transport sectors, the railway and the maritime sectors, are used to illustrate the proposition. In both sectors we observe discourses based on generic approaches to safety management and an accompanying disempowerment of the practitioners and their perspectives.

We discuss some contributing elements to this development: for example, the roles of external and internal HSE-specialists and the increased importance of international standards. We propose that the search for broad generalizations and the widespread adoption of cybernetic thinking in safety science may resonate with societal trends towards standardization and bureaucratic control.

We conclude that safety scientists, safety professionals, and organizations that hire safety professionals need to be sensitive to the possibility that their well-intentioned efforts to promote safety may lead to a marginalization of local and system-specific safety knowledge.

1   Introduction

The aims and scope of the journal *Safety Science* include the following statement: "*Safety Science* will enable academic researchers, engineers and decision makers in companies, government agencies and international bodies, to augment their information level on the latest trends in the field, from policy makers and management scientists to transport engineers" (Safety Science, no date). This statement corresponds to the common-sense notion that the applied sciences produce information that can be disseminated to practitioners. The

practitioners will increase their knowledge base and, as a consequence, increase their capacity or power to handle safety challenges. Knowledge is seen as additive and empowering.

The purpose of this paper is to explore an alternative view on knowledge and power. We propose that the introduction of management regimes based on generic safety management principles and international standards may displace or marginalize existing local and system-specific safety knowledge. According to this proposition, the knowledge produced by safety scientists and propagated by safety professionals is not just added to the existing knowledge of the practitioners at the receiving end, and it is not necessarily empowering when it reaches the practitioners (see also Daniellou et al., 2011). Generic safety knowledge may be embedded in a discourse (Foucault, 1972; Jørgensen & Phillips, 1999) in which the local and system-specific knowledge of the practitioners is marginal, irrelevant, or even meaningless. Safety professionals may gain a model monopoly (Bråten, 1983; 2000) in their interaction with practitioners. This will not only put the practitioner in an inferior position with regard to power; it can also obstruct mutual learning in the relationship between safety professional and practitioner. When organizations adopt management regimes based on generic safety management principles, this also influences reporting lines and regulation. We specifically discuss how international standards and regimes of accountability built around these principles act as drivers of professionalization and compartmentalization of safety. In this discussion, standards for how work is performed and safety is managed are our primary concern, and less so technical standards. The intricacies of how technical and process standards are connected make up an interesting topic in itself that should be explored elsewhere. Almklov and Antonsen (2010) note, for example, how standardization of components and parts of electricity grids is important for management to control work on it through standardization and accountability based methods.

In our discussion, we contrast generalized theoretical knowledge with knowledge that is more specific to local contexts. Where work is performed, people gain experience of the peculiarities of the technological systems and their surroundings and how to work in the specific context. Some of this knowledge is personal (Polanyi, 1958), as the know-how and perceptive skills of expert practitioners often involves non-verbal skills (see Dreyfus & Dreyfus, 1986). The knowledge may be shared by a limited community of practitioners (Lave & Wenger, 1991), or documented in rules and procedures that are specific to limited contexts. The focus on the tacit dimension of experience based local knowledge does not mean that it is unrelated to more abstract and generic procedures. Often, experience-based knowledge is essential in order to make more formalized systems work smoothly. Still, throughout this paper we will refer to the local and system-specific, experience-based technical and practical knowledge forms that are specific to singular contexts, in contrast to generic formalized management principles that have been designed to be movable across sectors and systems.

The theoretical basis for our discussion will be reviewed in Section 2 of this paper. Our study's methods are described in Section 3. In Sections 4 and 5, our propositions are illustrated by case studies from two Norwegian transport sectors, the railroad and maritime sectors. In Section 6, we summarize the results across the sectors and discuss the role and responsibilities

of safety science and safety scientists with regard to marginalization of local and system-specific knowledge and disempowerment of practitioners.

2   Theory

In the exploration of the foundations of knowledge and power in safety science, we use theories of how power and knowledge are connected. In the empirical section, we observe a change in the distribution of power between practitioners and specialists, and how this change is influenced by specific regulatory practices and organizational discourses. In the following, we present some of the key inspirations for this discussion.

2.1   Power and Discourse

A central premise for this paper is that social phenomena are socially constructed, and they are always in the making. The ways in which we speak and write about things do not neutrally reflect the world. Discursive practices play an active role in creating and changing identities and social relations (Foucault, 1972; Jørgensen & Phillips, 1999). A particular discourse (for instance, a particular way to speak and write about hazards and safety) may gain hegemony. It then becomes taken for granted or naturalized. As a consequence, alternative ways to speak and write about things may become irrelevant or meaningless. In this way, discourses may become carriers of both knowledge and power, and specific discourses may reflect the interests of particular groups.

In the present study, we want to explore whether knowledge produced by safety science meets the practitioners in the form of new discourses – or hegemonies – about safety. To the extent that this is the case, we want to explore whether the existing safety knowledge of the practitioners is marginalized in these new discourses. As a first step, we will suggest that there exists a safety discourse that emphasizes accountability and standardization.

2.2   Accountability, Standards and Knowledge Mobility

There are some overall societal and scientific developments related to the discourse of safety discussed here. First, the current regulation of safety should be seen in context of the "Audit Society" (Power, 1999; see also Power, 2007). In recent decades, societies, institutions, and companies have developed an intense interest in formalized methods for checking and follow-up activities. There are "deep-seated institutional pressures to make risk management practice auditable" (Power, 2007: 153). Both in the public and private sector, there is an increasing tendency to regulate and follow up on safety through audits and accountability regimes (see, for example, Hohnen & Hasle, 2011).These methods are means of providing transparency and control by

> *... spelling out institutional procedures and decision rules that would otherwise be implicit, and establishing paper audit trails or their electronic equivalents. Those developments allow auditors and inspectors of various kinds – the exploding world of 'waste-watchers, quality police and sleaze-busters' (Hood et al. 1999) – to verify that the written rules, procedures and protocols have been followed (Hood, 2007: 1996).*

Safety management has become subsumed by the more generalized accountability-based mechanisms of governance that dominate today. An example is the trend towards increased reliance on internal control and self-regulation, where companies are expected to have transparent standardized systems for control. For external auditors and authorities, it is primarily the *systems* that are subject to control and regulation (Power, 2007). In contrast to the command-and-control structures of the last century, in which leaders had more holistic responsibilities and authority, the regimes of accountability are narrowly concerned with the specified items by which individuals at different levels are held accountable.

Standardization is a method of making accounting objective and excluding personal judgment (Porter 1995:90–98).When tasks and targets are standardized and measurable, performance can be compared across sites. Moreover, it can be done with the "mechanical objectivity" (Porter, 1995:4) of measurement and accounting-based methods. As such, standardization is an intrinsic element of the audit society. These developments are also crucial elements in the rise of management as a profession, and "managerialism" as a way of governing companies and institutions (see Power, 2007; 152ff; Pollitt, 1990)

International safety standards should be seen not only as attempts to ensure safety and interoperability but also as a means of making safety work transparent across contexts. If workers perform tasks as the standards prescribe, they are compliant, at least from an accountability perspective, and this compliance is transparent to regulators and others without having to further investigate details of the local setting. Standards are a means of making information mobile across contexts (Bowker and Star, 1999; Latour, 1987; Almklov, 2008).

When safety science is introduced into organizational practice as safety management systems or regulations, it is, as we will demonstrate, formulated within the dominating discursive modes of accountability and standardization. These, we will propose, tend to favor systematic disciplinary knowledge over local unique personal expertise, in terms of what is regarded as valid knowledge.[1] One of Antonsen's (2009:1123) informants, in a study of culture and safety on offshore supply vessels, illustrates this neatly:

> *You know, good seamanship, it is tragic, it is about to disappear completely. That expression, 'good seamanship', it doesn't exist anymore, because everything that is to be done, has to be written on a list. You are not supposed to use good seamanship and common sense, you are supposed to use check lists, procedures and maintenance lists. That's what it's all about. And I know this is a source of great annoyance to the guys on the deck.*

Decisions and activities enter the systems of accountability by being performed and described according to standards. The bureaucratic methods of accountability depend upon activities and situations of each local context being translated into slots on the accountants' sheets.

In the present study, we explore whether a similar marginalization of local and system specific knowledge could be observed as the safety regime's focus on accountability and/or standardization reaches the railway sector and the maritime sector. We will also explore

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[1] For a discussion of standards as "recipes for reality" and the related power dimension, see Busch (2011).

whether the implementation of standards causes a shift in the power-balance between the actors in the local operational context and the generic expertise and control functions. This exploration will be informed by Bråten's theory of model monopoly and principal-agent theory.

2.3   Model Monopoly

Bråten (2000:105) points out that information is only useful to the extent that we have appropriate models that enable us to process and utilize that information. A *model monopoly* occurs when the domain of discourse is delimited in such a way that only one actor has access to a rich repertoire of relevant concepts and ideas, whereas the other actors are lacking such symbolic resources. We may refer to the former actor as model-strong and the latter as model-weak. Being the weak part in a situation characterized by model monopoly obviously leads to powerlessness. One may even have extensive knowledge about the issues at stake, but still be unable to utilize this knowledge effectively in a dispute. Model monopoly implies that the model-strong actor has a monopoly on the model, but it also implies that the model has a monopoly on the model-strong actor. The model-strong actor is restricted to a single, closed perspective, which excludes alternative interpretations of the situation.

According to Bråten (1983:25; 2000:105), attempts to share model power are likely to preserve or increase the power difference. The model has usually been developed to reflect the perspectives and interests of the model-strong actor. The model-weak actor is thus led to adopt the perspective of the model-strong actor, and this perspective is tacitly accepted as the only valid perspective on the issue at stake. Moreover, by sharing parts of his model, a model-strong actor increases his ability to simulate the responses of the model-weak actor, and he even gets some control of the capacity of the model-weak actor to simulate other actors' reactions.

The key is to resolving a model monopoly is to cancel one or more of the conditions that promote it (Bråten, 1983:26; 2000:21). This can be done in several ways:

1. Re-define the domain (universe of discourse).
2. Introduce complementary or competing perspectives that offer alternative or transcending terms.
3. Develop pertinent knowledge on the model-weak actors' own premises.
4. Evoke rival knowledge sources, or take a meta- or boundary position, crossing the boundaries of the domain.
5. Be aware of one's own tendency towards consistency and conformity with a monolithic perspective that silences the question horizon.

2.4   Agency theory

A common topic in political science and economics, is the dilemma that may occur when "an activity or the power of one of the actors—*the principal*—is delegated to [..] another individual—*the agent*—because of his specific competence" (Trontin & Béjean, 2004: 122; see also Eisenhart, 1989; Rosness et al., 2012). In this paper, we discuss the roles of safety professionals as intermediaries and as agents who aid the sharp-end workers with implementing and

interpreting safety management systems. The dilemma is that the interests of the agent (for example, the safety consultant and their customers/principal), are not perfectly aligned. The consultant may, for example, be interested in landing a follow-up contract as well as performing the ordered work, or maybe of making the safety management systems more generic to ease his own work. This may be a part of the explanation for the development of a more generic, standard-based approach to safety.
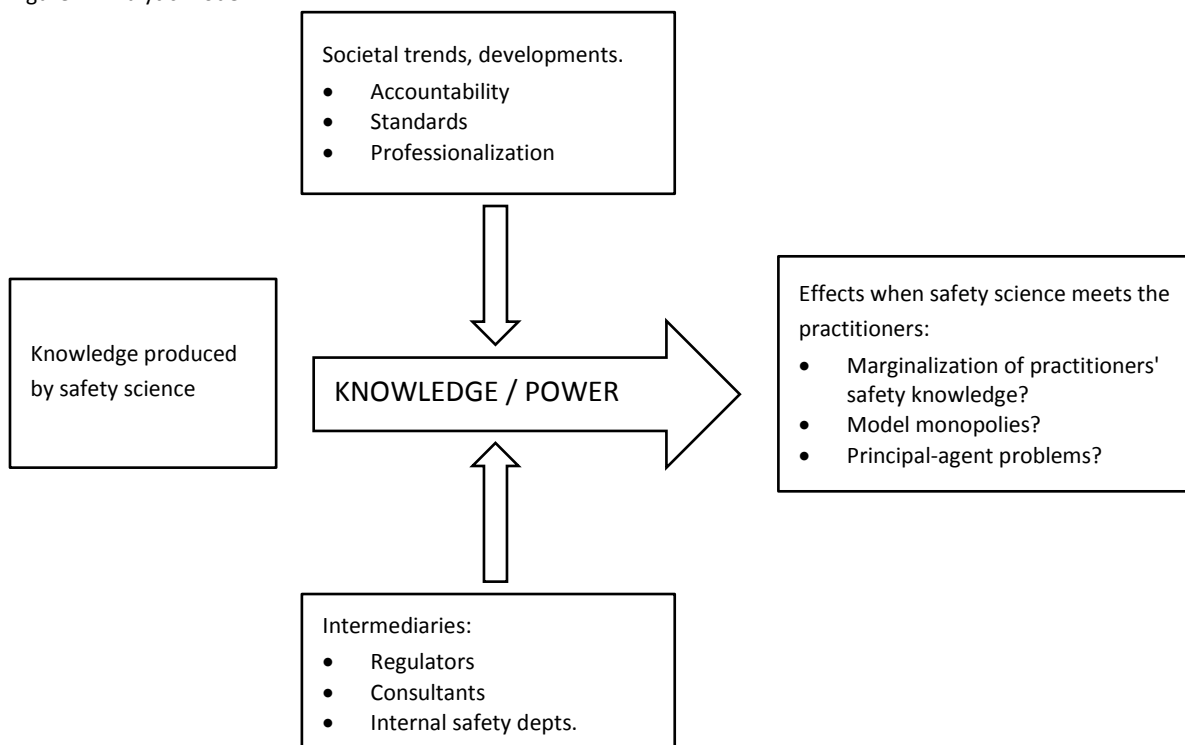
In the present study, we explore whether a model monopoly may occur when safety science reaches practitioners in the context of new regulatory regimes, focusing on accountability and standardization. We will also explore whether practitioners may become the weak part in principal-agent relationships with authority representatives and consultants, due to information asymmetry.

3   Method

The overall approach in this study is abductive in the sense that cases are "interpreted from a hypothetic, overarching pattern, which, if it were true, explains the case in question"(Alvesson and Sköldberg, 2009:4). We include two complementary cases because abductive explanations need to be strengthened by new observations.

Though we will focus our discussion on these cases, the paper is inspired by a longstanding interaction with Norwegian transportation and infrastructure sectors, and observations from diverse projects (Almklov & Antonsen, 2010, Fortcoming; Antonsen et al., 2010; Blakstad et al., 2010; Guttormsen et al., 2003; Rosness, 2008, 2009, 2013; Størkersen et al., 2011)

Figure 1: Analytic model

Societal trends, developments.
- Accountability
- Standards
- Professionalization

Knowledge produced by safety science

KNOWLEDGE / POWER

Effects when safety science meets the practitioners:
- Marginalization of practitioners' safety knowledge?
- Model monopolies?
- Principal-agent problems?

Intermediaries:
- Regulators
- Consultants
- Internal safety depts.

The study is guided by the analytic model shown in Figure 1. Our main interest is what happens when the results of safety science meet the practitioners (the horizontal arrow). Our focus is on knowledge and power, which we consider inseparable. However, in order to construct a plausible account of this, we propose that it is necessary to take into consideration (1) current societal trends towards accountability, standardization, and professionalization, and (2) the actions and practices of intermediaries such as regulators, consultants, and internal safety departments.

The first case is a historical analysis of the Norwegian railway sector, with emphasis on the last twenty years. The study draws heavily on a recent history of Norwegian railways (Bergh, 2004; Gulowsen & Ryggvik, 2004), but is also based on primary documents (Traffic Safety Rules, a Safety Handbook and public accident investigation reports), interviews, consulting experience (e.g., *Ref Blinded*), a study of rule development (*Refs blinded*) and informal discussions with railway personnel. The historical study is supplemented with recent interviews focusing on regulatory issues in the ongoing RESCUE (*Regulative rationalities and safety culture*) project.

The second case study is a snapshot of some maritime transporters' view of safety work today. The data for this part is drawn from two projects: RESCUE, which is still on-going, and the recently finished Safety in Cargo Shipping (See Størkersen et al., 2011) , which was conducted for the Maritime Directorate of Norway. Together, these projects contain interviews with around 80 seamen on passenger boats and cargo ships. Safety in cargo shipping also included around 300 hours of observation on cargo ships. Important information for the present discussion also comes from interviews with managers, interest organizations, and authorities conducted in these projects. We have, however, only analyzed and employed the most relevant interviews for this paper, the interviews where the topics of concern were explicitly addressed. Though these most relevant interviews are extensively quoted, they are also supported by observations and interviews throughout the projects. Quotations should not be seen as evidence themselves, but as illustrations of our insights drawn from the total body of interviews and observations.

Longstanding and recursive interaction with the industries gives opportunity for triangulation, cross checking, and discussion of our observations. Qualitative interviews combined with document studies and surveys are also methods that give an explorative edge, the opportunity to uncover unexpected phenomena, while retaining the possibility of checking for generalizability. Since the data are drawn from independent projects, they give different angles and at least an element of confirmation of findings. In sum, we are convinced that our findings are robust (see Section 6.6.), but their generalizability to other sectors and countries needs to be explored elsewhere.

4 Confrontations between two safety regimes in Norwegian railway administration

The first case is a historical account of confrontations between two safety regimes (i.e., two constellations of knowledge, norms, and formal authorities) on Norwegian railways.[2] We shall contrast "the old regime," centred on the distinctive characteristics on railway technology and

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[2] The term "safety regime" is inspired by Slagstad's (1998) notion of "knowledge regimes."

operations, with the "new regime," based on generic safety management principles. We shall then outline a series of confrontations between the two regimes.

4.1   The old regime

The old regime was as old as the railways themselves in Norway. The first public railroad, which was opened in 1854, adopted technology and safety rules imported from UK. The regime has evolved over time, as a function of new technological opportunities and learning from accidents. Regarding knowledge content, the old regime focused on the risks peculiar to railways and the specific technical and administrative means to keep these risks under control, such as signalling systems and traffic safety rules. This can be illustrated by the chapter headings and associated maxims from a book manuscript written between 1957 and 1961 by the head of the safety office of the Norwegian State Railways (NSB), shown in Table 1. Most of the topics, and nearly all the contents of this book, are specific to railway operations.

Table 1: Chapter headings and maxims in the book " "Safety service at Norwegian railways during the first 100 years, 1854-1954" (Johannesen, 2007).

Chapter	Maxim
1. Introduction	Safety is the first and foremost requirement to public transportation
2. Laws and regulations	Safety is created by laws and regulations
3. Management of safety service	No safety without management
4. Signals and safety installations	Signal is symbol for safety
5. Safeguarding train movements on the line	No safety without a clear track
6. The trains' composition, equipment, speed, manning and inspection	Safety depends on the trains' composition, equipment, speed, manning and inspection
7. Shunting service	The safety of material and persons during shunting depends not the least on general carefulness and accurate judgements
8. Personnel	Well-equipped personnel warrants for safety
9. The relations of the public to safe operations	No safety for persons without personal carefulness
10. Accidents	Absolute safety does not exist
11. Safety conditions during the war 1940–1945	War is a threat to safety
12. Miscellaneous safety conditions	Safety has to be created under many different conditions and in many different situations.

This knowledge was considered core competence and a marker of identity among NSB employees. In particular, mastery of the traffic safety rules was a status marker because it was precondition for holding a number of positions, such as train driver, rail traffic controller and train dispatcher.These bottom-up safety rules were closely connected to practice and experience and the rule set had grown rather complex over the years.

In the heyday of the old regime, the safety office had a prominent position in the organization, and its head reported directly to the managing director of NSB. The prestige and influence attached to this position went far beyond that of an ordinary staff function (Gulowsen & Ryggvik, 2004). Moreover, NSB was still a monopoly company encompassing infrastructure management, train operations, and regulatory authority in the area of traffic safety.

4.2   The new regime

"The new regime" refers to a competing constellation of safety management principles with associated knowledge, administrative systems, and organizational structure that entered the arena in the 1990s. The knowledge content and prescriptions for safety management associated with the new regime was generic. This is illustrated by the following excerpt from the public investigation report after the train collision at Åsta on January 4, 2000 (NOU 2000:30 p. 141, our translation). The text could equally well have been applied to an offshore petroleum installation by replacing the term "railway activities" with "petroleum activities."

> *Safety management refers to the activities of a safety-related character concerning organization, responsibility, processes, and resources that are required to direct and manage railway operations. Safety management is an organizational process that encompasses many steps, from strategic goals to evaluation of results.*

> *Safety management includes both the daily work, with checking that everything functions as it should, as well as a comprehensive assessment of risk and changes. These two forms are of different character. The daily work is of a practical nature and characterised by the need for somebody to be present all the time for safety to be adequate. The comprehensive assessment or the risk analysis is abstract and characterised by a comprehensive view and assessment of changes.*

In this text, the core knowledge associated with the old regime is "black-boxed." This knowledge is necessary to accomplish the objectives of safety management, but it is not visible in the text.

The new regime was associated with changes in authorities and power. The first step was the appointment of a Director of Health, Safety and Environment (HSE) in NSB in 1993. This step was a response to the introduction of internal control (enforced self-regulation) of HSE in the Norwegian work environment legislation. The head of the safety office was subordinated to this position, moved two tiers down the management hierarchy, and thus lost his direct reporting link with the managing director of NSB. The knowledge domain of the old regime was subordinated to the broader domain of HSE.

4.3   Confrontations, cohabitation and rapprochements between the two regimes

A major confrontation between the two regimes occurred after a train collision at Nordstrand in 1993. The Director of HSE issued a memo criticising the safety culture and the safety systems in NSB (Gulowsen & Ryggvik, 2004:433, our translation):

> *… according to my impressions, the [safety culture] is characterised by a lack of clarity …, it has inadequate foundation in systems and management, it is technologically conservative, it is based on a very comprehensive set of rules which to some extent need modernizing and updating, it is not properly integrated in the HES philosophy and the internal control scheme.*

This was a head-on attack on the old regime, and in particular the safety office. The Director of HSE also chose to let an independent research institute investigate the Nordstrand accident,

thus setting aside the in-house accident commission of NSB, which was led by the head of the safety office.

In 1996 the Norwegian State Railway (NSB) was divided into an infrastructure administration, The Norwegian National Rail Administration, and the new NSB, which was gradually reduced to a train operator. This step served to open Norwegian railway infrastructure for other train operators. At the same time, a separate regulatory authority, the Norwegian Railway Authority, was established.

The Railway Authority initially hired only two persons with a background from railway safety. The first two managing directors, as well as many of the staff, had a background from safety work in the petroleum sector.

The Railway Authority chose a regulatory strategy based on safety system audits rather than prescriptive requirements and inspections. Major audits were directed at the Rail Administration in 1998 and 1999. The conclusions were critical: in one of the audits the Railway Authority concluded that the Rail Administration lacked a visible safety management system (Gulowsen & Ryggvik, 2004).

In 1999 the Railway Authority introduced new safety management regulations that required the National Rail Administration and the train operators to establish a system for risk-based safety management. The Rail Administration responded to the new regulations by engaging two hired consultants to develop a safety management system. A *Safety Handbook* was released in 2000. The requirements in the Safety Handbook were mainly process oriented (e.g., requirements that technical modification and organizational change should be subject to a risk analysis) or outcome-oriented (e.g., risk-acceptance criteria).

After a train collision at Åsta with 19 fatalities on 4 January 2000, safety management at the National Rail Administration was severely criticized in a public accident investigation report (NOU 2000:30 p. 203).

> *Safety-consciousness and safety management, which in other comparable sectors have been basic principles for many years, have not been implemented in the former NSB and later in the Norwegian National Railway Administration. When the incident-based form of safety management on which safety on the railways has supposedly been based has not been followed either, the result is a system that will only discover that there are basic inadequacies in the safety of a section of line when an accident happens on that particular line…*

> *In the view of the Commission, the Åsta accident occurred because of basic inadequacies in the Norwegian National Rail Administration with regard to safety consciousness and safety management. This means that the effect that serious and in some cases well-known safety deficiencies on the Røros line had on safety were neither analyzed nor followed up. These basic deficiencies in safety management apply to all the aspects of the Norwegian National Rail Administration's activities that the Commission has examined and must therefore be regarded as a serious system failure.*

The climate that emerged in the Rail Administration after the train collision at Åsta gave impetus to the new safety management system. The safety management discipline gained recognition, resources, and top management attention. The event and the public reaction also

created an "unfreeze": i.e., a climate where people were willing to revise their unspoken values and basic assumptions and modify their practices accordingly. Both line managers and safety staff received training in safety management and risk analysis.

As a consequence of this new safety management regime, the Rail Administration has performed comprehensive risk analyses of all railway sections as well as numerous risk analyses related to technical modifications and organizational changes. The analyses have in several cases had an impact on decision making, by, for instance, forcing decision makers to clarify new roles and responsibilities before implementing organizational changes, or to modify the layout of new stations. Specialists in technical disciplines, such as maintenance management, found the safety management too general or abstract to give effective guidance to their daily work. They tended to rely on their own competence within their discipline in their efforts to maintain safety in their daily work while trying to be loyal to the requirements of the Safety Handbook.

A late encounter between the two regimes occurred when the Rail Administration started the process of revising the traffic safety rules in January 2000 (Blakstad, 2006; *Ref blinded*). In accordance with the new risk-based safety management regime, the intention was to apply a top-down risk-based approach to rule development. The project group tried to apply this top-down risk-based approach, but they did not find it viable. The project group did not fully trust that the proposed process would assure an adequate level of traffic safety. They therefore turned to a process that has been termed "reverse invention" of safety rules (Blakstad, 2006; *Ref blinded*). They used railway knowledge and existing prescriptive rules as the main basis for developing a modified set of prescriptive rules. They used risk analyses in an iterative manner to elaborate issues of concern, to check the quality of evolving rules, and to reveal potential dangers created by changes in the rules. Although the project group wanted to be loyal to the new safety management regime, they found it necessary to modify the approach suggested by the new regime radically in order to adapt it to the specific requirements and constraints associated with development of traffic safety rules for railways.

4.4   Restructuring of the sector and standardization of safety management.

Since the restructuring of the sector was intended to make room for external operators on the Norwegian railways, interoperability and compliance with European standards is now a dominating issue. These interoperability standards concern both technical operability and also the safety management systems of operators. Naturally, the standards are less adapted to the specifics of the Norwegian railroad network, as they are developed to be employed across the heterogeneous European railway network. As such, international standards are an intrinsic part and motivation of the new regime.

In the new regime, the operators are required to have a functional Safety Management System. The authorities mainly check that systems are in place. Some smaller operators have to rely on external consultants for the development of governing systems. This caused some concern with the authorities we interviewed as some operators did not have the required competence "in house" but in the form of contractual relationships. Consequently, the contracts

themselves, and whether the operator has sufficient control in the principal-agent relationship was a topic in their certification and inspection work.

4.5   Knowledge, power, trends and intermediaries in the Norwegian railway sector

Modern safety management principles did not reach the Norwegian railways in the form of discrete pieces of information that could be added to existing body of knowledge. What we have observed is rather a series of fierce confrontations between two knowledge regimes. The course of the confrontations and their outcomes were influenced by environmental contingencies such as new legislation, deregulation, and internationalization of the railway sector, organizational changes in the NSB, the establishment of a new inspectorate, and the Åsta accident. The new knowledge regime was represented by a series of intermediaries such as the Director of HES, the Railway Authority, research institutes, hired consultants, new safety staff at the Rail Administration, and the public commission that investigated the Åsta accident. The system-specific and local knowledge base associated with the old regime was a precondition for successfully adopting the new regime. However, this knowledge lost visibility and status, because it was peripheral to the domain of safety discourse defined by the new regime. At the same time, the main spokesman of the old regime lost formal authority as traffic safety was subordinated to the more generic HSE discipline. This loss of authority may have been a contributing factor with regard to the Åsta accident. The head of the traffic safety office warned about the lack of automatic train control at the Røros line in two meetings with Rail Administration senior management in 1995 and in two memos directed at the Rail Administration senior managers in 1996 and 1997 (NOU 2000:30 p. 153). An automatic train control systems is designed to stop a train if the driver fails to apply the brakes in front of a signal at danger, and it is possible that this would have prevented the collision at Åsta (NOU 2000:30 p. 150). The Rail Administration senior management did not react to these warnings. According to the public investigation report, the managing director of NSB could not remember having received the memo issued in 1996 by the head of the traffic safety office concerning the safety problems on the Røros line. The managing director also claimed that nobody in the organisation had said that installation of an automatic train control systems on this line could not be postponed. He further claimed that he, like many others, had been living in the belief that it was safe to drive on the Røros line (NOU 2000:30 p. 153). It is conceivable that the head of safety might have been more successful in drawing senior management's attention to this problem if he had a position of authority similar to that before the reorganization in 1993. The marginalization of the practitioners' knowledge may also imply a marginalization of their safety concerns.

5   Maritime standards, intermediaries and disempowerment

The previous section's historical discussion of the railway sector illustrates a transition between different regimes of safety management. The new regime implied a more generic and system-oriented view on safety, linked to international standards. This regime contrasted with

the rule-based system that had been closely linked to operational experience, specific to Norwegian railways.

This section's discussion of the maritime sector presents a snapshot of the same trends in which local operational knowledge is rendered less relevant as it is faced with safety regimes based on generic models of safety and international standards. For many of our informants, these are stories about disempowerment. Based on interviews, we will now discuss these developments and the role of the regulators and consultants as intermediaries.

5.1 Basics about the maritime safety regulation

The Norwegian Maritime Authority was organized in 1903 to control and supervise the safe operation of ships and seafarers in Norwegian waters (Norwegian Maritime Authority, 2012). A basis for their work is their national regulations, which also includes ratified rules from, for instance, the European Union and the International Maritime Organization (IMO) (Pettersen & Bull, 2010). The international regulations are established by consensus, which in most cases means that it takes time to implement changes. For instance, the International standard for the safe management and operation of ships and for pollution prevention (the ISM code) was first agreed upon by IMO in 1994, and in 2002 almost all international shipping was required to comply.

According to the ISM code, all ships are required to have a working safety management system. After the company has developed their safety management system for the organization and each vessel, they have to be controlled, certified, and thereafter audited every 2.5–3 years. The Norwegian Ministry of Trade and Industry (owner of the Maritime Authority) has delegated supervision authority, including ISM certification and revisions of shipping companies, to five consultant companies (also called recognized organizations). The Norwegian authorities have ratified the recognized organizations' procedures (NOU 2008:8). The recognized organizations are also operating as consultants developing safety management systems for shipping companies.

5.2 Disempowerment at the sharp end faced with complex regulation

More than the railways, shipping is an international industry. Most of the Norwegian-owned vessels in international shipping are flagged out, but in coastal shipping many vessels remain under Norwegian flag. Still, much regulation comes from international bodies, and national rules seldom deviate from these international regulations. In the interviews, our informants told how vessels owned by family businesses tried to make sense of and comply with a vast body of rules and regulations. In this work, most of them relied on help from consultants who possessed more knowledge of the system.

> We had as starting point, me and the consultant, that we'd make [our safety management system] as small and clear as possible. I think it was 43 pages. And now it's about … let's look in it … We've one operational guide and one quality plan … we can't get an overview over how many pages it is. (Master, passenger vessel)

No, we can't do anything. The only thing we can do is trying to find the easiest way to meet the demands. […] It isn't possible to argue against safety. And they can refer to all kinds of [regulations]. (Employee, maritime interest organization)

Since the regulation leaves limited room for local variation and the heterogeneity of the fleet, much of it is seen as unnecessary, and even as a threat to safety, due to increased workload and changed focus to administrative work.

If you're to have so much reporting and governmental surveillance and there's no sensible reason for it… it becomes a risk. It had actually been fronted by both the Maritime Officer's Association and the Federation of Norwegian Coastal Shipping on [a conference] that the safety demands are a threat to safety. (Management, maritime interest organization)

The safety systems are built around accountability and the principle that safety is documented by following up a standardized set of items. This results in a heavy burden of reporting.

And often we feel that the new requirements… are pure, unadulterated abuse some times. And has little to do with carrying out safety work. Like the ISM and these things. It's a set of rules and it's a rule of red tape. This is one of the things we've worked with the Maritime Authority about; limiting all the demands from the authorities that concern reporting. That really works against safety in my opinion. (Management, maritime interest organization)

5.3   Standards and reporting

You can't expect the same of sand-boats[3] as with an [oil.-tanker]. But they are subject to the same regulations. So [the inspector] at a sand-boat should have some sense of reality … (Employee, maritime interest organization)

Safety management is to an increasing extent built around international standards, and by systems based on accountability and transparency. The national supervisory body typically makes minimal changes while adapting European rules to the Norwegian context. The rules, which are international and made to be applicable in several different settings, are more complex, more abstract, and less locally relevant than what is optimal for each setting. Deregulation and international competition is a key driver of this trend towards standardization. Common rules level the playing field. They must also be supervised and regulated in a transparent and accountable manner, so as to avoid preferential treatment for local operators. The quotations above illustrate the local implementation issues for systems that are standardized across contexts and nations. The process of standardization can be problematic and painful, but this should not be seen as an argument against standards as such. Standards are attempts to convey good safety knowledge in a fair and transparent manner, without hampering competition. In the case of national regulation, for example, safety demands can be used politically to exclude transporters from other countries. Standards are political.[4] When

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[3] These vessels typically transport sand or gravel along the coast. They have a crew of less than a handful and travel short distances.
[4] See also Busch (2011) and Bowker and Star (1999).

discussing IMO's workour informants stated belief in their good intentions when creating international safety regulations, but felt that these intentions often disappeared when they were translated into the standards.

What we observed in the maritime shipping industry was that the ISM code and the demands for a systematic and generic approach to safety meant that many companies needed help with translating, implementing, and satisfying the system.

5.4   Intermediaries –safety consultants and authorities

Several of our informants discussed how the companies were becoming increasingly dependent on the consultants to translate regulations to practice and help them develop a management system and report according to the accountability-based systems. When the ISM code first was implemented about ten years ago, the maritime organizations did not have competence in building the safety management systems that the code demanded. As the international standards are abstract, detailed, and complicated, and the work involved in translating these to practice in the individual vessels is comprehensive, external safety specialists were needed as brokers and translators of the standardized and accountability based regimes.

It's amazingly many working in safety. How many lectures we've been to and listened to about how the world isn't able to survive if we don't have all these safety companies. It surely has become an industry. (Management, maritime interest organization)

[The consultant company] have never earned as well as after they got the ISM. I know many competent people in [this consultant company], but after ISM everything is going on paper to be documentable. I have written deviations and commented the formulations on the deviations, and they are sent back and forward. It's silly. (Master, cargo vessel)

The importance of the consultants and their knowledge has grown, and there is a growing industry helping the shipping companies to comply with regulations. Some also see it as a problem that the Maritime Authority has delegated the ISM certification to third-party consultant companies. The following quotation may illustrate how the international standards give leverage to the consultants, as important interpreters, while the Maritime Authority is perceived as powerless when faced with international regulatory initiatives. This informant recounts his observation of two lectures at a conference to illustrate his point:

… the IMO-representatives stressed that here the national authorities had to have a firm hand on [the safety systems] and not leave it to every company to develop. They said that very clearly. The Maritime Authority people were more or less sitting there with their heads bowed. And next speaker on the program, that was the guy from [a consultant firm] who was talking about now there'll be two days of extra inspection aboard.[…]The [authorities] let the recognized organizations develop after their own needs. And then we're back to the industry we talked about again. (Management, maritime interest organization)

It is quite evident that the knowledge about safety management, and the standards and accountability regimes in which much of it is inscribed, is subject to power struggles. To disentangle what is pure knowledge and what is pure politics or power from these struggles is

not possible, and consequently the observations from our informants are more indications that a struggle is going on than an unbiased description of the nature of it. An interesting aspect of the role of the consultants as intermediaries is the principal-agent dilemma they pose. The consultants are hired to help the companies comply with regulation and, hopefully, to help them improve safety. One could assume, however, that they also have an interest in being relevant and useful so as to be hired again. The shipping companies see an industry developing. We do not question the usefulness and good intentions of this industry, but as in all principal-agent relationships their interests do not fully overlap with that of their clients.

The misalignment of over-complex systems to the realities in Norwegian coastal transport and the ambiguous role of consultants was the self-proclaimed rationale of a unit in the maritime interest organization we visited. The unit was established to help their member companies in the work of transforming abstract standardized regulation and rules into workable internal procedures and documentation. Their main interest was in making the systems simple and usable, and not necessarily primarily to satisfy "every comma in the rulebook."

> *Something that's a concern is that there are made so many new regulations all the time. There isn't enough time to follow the jungle of regulations. Large challenges. The ISM code's very simple in itself if you get to know it. [..]Knowledge about ISM code can be boiled down to a very simple standard. (Representative, maritime interest organization)*

The organization sees their members losing power when faced with specialists mastering complex regulation. The unit can be seen as a response to this development challenging the perceived model monopoly of the specialists, trying to stick to the simplest possible implementation of the ISM code.

Though the difference between sectors is distinct, we see here as in the railway case that generic safety management principles, international standards, and accountability regimes leaving paper trails emerge as distinct entities that challenge the relevance of experiential knowledge specific to unique sites or operations.

6 Discussion

In Section 4 and 5, we discussed a shift in towards a more generic and theoretical view of safety and accompanying shifts in power relations in railway and maritime organizations. The local experience-based knowledge seems to be rendered irrelevant in the more theoretical and generic discourse of safety contained in standardized, accountability-based systems. We will now discuss the consequences of this shift in safety knowledge and power, how the new systems and standards might result in safer operations or repress the original safety knowledge – and why these findings should be of concern to safety scientists.

6.1 Marginalization of system-specific and local safety knowledge

Throughout the empirical section, we have seen changes that cause proponents of safety knowledge embedded in operational procedures and situated practices to lose impact in decision processes. More "organic" ways of working with safety are increasingly been displaced

by safety as a discipline and topic external to the specifics of everyday operations. System-specific and local safety knowledge has traditionally been hegemonic in both railway and maritime transportation. Good seamanship and the experience-based rules in the railroad systems is knowledge that is specific to the sector, to specific systems, and sometimes also to more local contexts in which individuals work. Several mechanisms may have contributed to a loss of this hegemony, or marginalization of traditional knowledge, when new safety management requirements were introduced in the two sectors. The new safety management requirements were based on generic management principles rather than system-specific safety strategies. In the railway case, a new safety discourse highlighted generic safety management activities, whereas the system-specific activities and knowledge were subordinated or not mentioned at all, as illustrated in Section 3.2. In the maritime transportation case, the focus on documentation of procedures made tacit system-specific or local knowledge irrelevant – unless it could be codified in the form of new procedures. As a consequence, more system- or context-specific knowledge forms were marginalized or assimilated to the new procedural style.

Regulatory and management attention was directed at the development and implementation of the new, safety management systems, and to the follow-up activities prescribed by these systems. System-specific and local knowledge may also be marginalized in an organization if its spokespersons lose authority and influence. In the railway case, the main spokesman of the system-specific safety knowledge, the head of the traffic safety department, lost status and direct access to the managing director when the Director of HES was appointed in 1993.

The marginalization discussed here does not necessarily imply that the system-specific knowledge went out of use. This knowledge was still necessary to operate trains and ships in a safe manner. Rather, marginalization implied that the system-specific knowledge lost status, attention and impact in the organizations. Experiential knowledge accumulated over decades, both in its explicit and in its implicit forms, was subordinated to more generalized models and systems of safety management.

6.2   Compartmentalization of safety and disempowerment of the practitioners

New actors entered the scene in both cases. In the railway case, we noted the appearance of the Director of HES (and his staff), the new regulatory authority, consultants engaged to develop a safety management system for the Railway Administration, new safety staff, and the members of the public commission that investigated in Åsta accident. In the maritime sector, the last decade's implementation of the ISM standard has generated a market for consultant companies and HSE officers, developing and revising safety management systems for the shipping companies and vessels. These new actors were in most cases outsiders to the communities of practice that operated railways and ships. As a consequence, safety became a separate discipline, more detached from the practice field.[5]

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[5] See Amalberti (2013) for more about the emergence and compartmentalization of the safety field and consequences for industries and regulators.

The consultants and safety professionals, we have argued, possess not only knowledge of the systems through which work is governed, but also model power. In our data, there are repeated stories of how practitioners experienced disempowerment when confronted with standardized safety management systems and their representatives. Their arguments and concerns were marginalized in the new, generic safety discourse. In some cases, they lost formal authority or access to senior management. In discussions about safety, they often became the weak part in a situation characterized by a model monopoly. Moreover, they were not in a position to break out of the model monopoly by redefining the domain of discourse, because the models were introduced in the form of mandatory regulations or standards. This weakness is doubly important given the fact that the safety specialists are often agents in relationships characterized by principal-agent dilemmas: The agents hired to help a company with the safety systems do not necessarily have the exact same interests as their principal. We have suggested that at least in some cases, it can be in the interest of the hired safety specialists (the agent) to work with more standardized systems and systems that require less local adaptation.

6.3   Standardization and professionalization of the safety field

In both our empirical cases we have noted an increased focus on accountability. Safety work should leave a "paper trail" for management and authorities to inspect and compare with other sites. What we have discussed is a development where risk and safety management becomes a subset of the management systems in general (Power, 2007). A prominent example of this is the internal control regime, which is built on standardized, transparent, and auditable information flows. Working and reporting according to standards necessitates translations of one's specific context to the standardized categories when reporting, and when working according to standards, translating, and situating the requirements to one's own specific context (Almklov and Antonsen, 2010). This development is best illustrated by our discussion of ISM regulation to small cargo vessels, and is connected to the compartmentalization of safety work (see section 6.2). Safety management governed by the ISM systems and generalized self-regulation of HSE in the railway sector is less connected to the situated practices in which work is performed. All representations of work need to be translated when put into action. They can be treated as resources for action, rather than recipes to be followed mindlessly. As the example with the maritime interest organization suggests, skilful navigation within the new regimes is possible. As such, a crucial topic for safety research is to understand the translation processes between rules and regulations and practice, beyond compliance and non-compliance, including the role of intermediaries.

6.4   Implications for safety

To be relevant and effective, a safety system must be anchored in, and relevant for, local practice. The changing power relations associated with the marginalization of local and system-specific knowledge may affect the ability for practitioners to convey their concerns and

observations and for the relevance and utility of the system.[6] Important experience may be lost as it must be filtered through a standardizing discourse and the models of safety professionals.

It is outside the scope of the present study to assess the combined effects of new safety management systems on safety. We acknowledge that dedicated brokers in many cases are able to make standardized systems useful in practice (as shown by for instance Kongsvik et al., in press). Daniellou et al. (2011) emphasize the managers' responsibility in translating practical knowledge to the safety management systems, and vice versa. The observations here are still warnings of a possible downside of these developments. We need to consider whether the reliance on standards, the accountability explosion, and the compartmentalization of safety management may weaken typical resilience-generating factors of organizations. A central idea in Resilience Engineering, for example, is that variability in how work is performed may also contribute to improved safety (Hollnagel et al., 2006; see also Rasmussen, 1997 and Roe & Schulman, 2008). Generic safety systems geared on standards and control are likely to reduce not only harmful deviations from procedures, but also the adaptations that might make work more resilient. Rigidly structured work, void of joyful exploration (Rasmussen, 1997: 193) and creative adaptations may also over time lead to de-skilling at the sharp end. Also, the weight put on transparency and paper trails may lead to focus on avoiding error and "managing to audit" (Hood, 2007: 207), which may hamper typical resilience-generating creativity. If one's every action must be by the book, one may face strong incentives to manipulate information flows to avoid blame (Hood, 2007; see also Dekker, 2007). One can experience that compliance is only on paper, decoupled from practice.

6.5   The role and responsibilities of safety science and safety scientists

Safety science is a science with ambitions of being useful and applicable. Consequently safety scientists need to take into account power issues related to the knowledge they produce and promote. Safety management systems and standards are informed by safety research, but they are also shaped by the dominating management discourses (Power, 2007). If the dominating mode of governance is checklists and paper trails, our research is likely to end up as another item on the list or another report required from the sharp end. We have noted a distinct displacement of discursive hegemony towards a more systemic conception of safety in safety management. We have also noted a corresponding displacement of power from the spokespersons of local and system-specific safety knowledge to the advocates of generic safety management principles. We need to consider to what extent and how safety science contributes to these displacements of hegemony and power.

The direct implication of safety scientists in developing and implementing new standards and regulations was rather limited in the cases presented in this paper. Research institutions have assisted the Norwegian State Railways and the National Rail Administration in their efforts to comply with new safety regulations, but the volume of this assistance is small compared to that provided by consulting firms. A few persons have migrated between research institutions,

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[6] Almklov &Antonsen (forthcoming) suggest that important aspects of continuous operational work fail to be captured in standardized documentation systems.

consulting firms, and the organizations that have been subjected to the new regulations. These persons may in some cases have acted as mediators between generic and system-specific safety knowledge. However, we are not aware that safety scientists have played any major part in the development of the regulations and standards referred to or the decisions to implement those standards.

Safety scientists may have played a more important role through the contents and directions of their research and the tacit or explicit assumptions on which this research is based. Scientists tend to seek generic explanations and theories that are applicable across cases. Haavik (this issue) suggests that theories such as High Reliability Organizations, Normal Accident Theory and Resilience Engineering are all fundamentally relational in their origins, and that they are all frameworks initially conceived "bottom up" from detailed studies of situated sociotechnical relations and practice. Later on, as they are included in the theoretical body of safety science, these insights are typically reframed as generic principles and the importance of situated studies is lost. The tendency within the scientific discipline to generalize and the systems through which safety is managed in the industries challenge more local understandings, situated in specific sociotechnical systems with specific contexts. Many frameworks and theories also aim to understand the context specific variability and practices. Still, there is reason to ask whether even the most context sensitive observations and theories are able to inspire safety management that is not geared on accountability and standardization. Given the by now well founded assumption that experience-based creativity and situational adaptation is important in some situations, it is a critical challenge for safety science as an applied discipline to be able to propose organizing models and systems that support these abilities.

The search for broad generalizations in safety science has also led to a relative scarcity of theory and research addressing differences between systems and sectors and the implications of these differences for safety management. One theorist that makes such differentiations is Perrow (1984), who proposes that tightly coupled technologies require centralized control structures whereas technologies with complex interactions require decentralized control structures. Another example is Rasmussen's (1997) proposal that different risk control strategies are required for domains with, respectively, (1) frequent, small-scale accidents, (2) major accidents, and (3) large-scale accidents (e.g., nuclear power plant melt-down). Safety science could make the value of system-specific and local safety knowledge more salient by providing more insight into the need for differentiation of strategies and means for risk control.

Another aspect of the safety scientists' role in the knowledge shift is the widespread adoption of cybernetic thinking, with its focus on control, deviations and feedback. Such thinking tends to resonate with the focus on accountability and traceability observed in the present study, because control loops are often relatively easy to "translate" into administrative controls. We do not deny the value of cybernetic thinking in safety science, but safety scientists need to be aware of the limitations of very simple cybernetic models. These models rarely differentiate between systems with different properties, and they may thus be used to justify generalized and undifferentiated safety management strategies. Moreover, very simple cybernetic models are rarely falsifiable. A model prescribing that companies should discover all significant hazards by

means of feedback systems and feed-forward analysis, and then select and implement effective risk reduction measures against these hazards will be "confirmed" by any accident, since the occurrence of an accident logically implies that some hazard has been undetected or that effective risk reduction measures have not been implemented. Cybernetic thinking may, on the other hand, be used to differentiate between the control problems associated with different systems as illustrated by the examples of Perrow (1984) and Rasmussen (1997) mentioned above.

Some of our most cherished academic virtues, such as precise definitions, consistency, and exclusion of irrelevant facts and arguments may at times promote a model monopoly. The most important symptom of this circumstance is perhaps the apparent absence of tensions and the apparent ease with which contradictory evidence can be defined as irrelevant or reinterpreted to be in harmony with our model. Such apparent absence of tensions is not a very strong signal. With reference to Bråten's theory of model monopoly, safety scientists may consider (1) whether their research tends to define a domain of discourse that excludes the voices of practitioners, (2) whether their research invites practitioners to contribute complementary or competing perspectives of their own, (3) to what extent the knowledge they produce reflect the premises and interests of potentially disadvantaged actors, (4) whether their research can challenge dominant knowledge sources that have established a model monopoly, and (5) whether their own research efforts have been captured by a model monopoly with a monolithic perspective. Challenging model monopolies may enhance the diversity of organizational sense-making with regard to risks and thus contribute to the "requisite imagination" (Westrum, 1993) or "conceptual slack" (Schulman, 1993) of the organization. It may also counteract tendencies to ignore warnings that are at odds with the dominant beliefs and norms in the organization (Turner & Pidgeon, 1997).

The development of standards and regulations involves generalization of safety knowledge from operations through companies, interest organizations, scientists, regulators, politicians, and others (as shown by Rasmussen 1997), to the international organizations and in the conventions and standards. After it is standardized and ratified, the knowledge will again have to be translated and adapted to the local context. This translation work will be done by the same regulators, companies, operative personnel, and possibly safety scientists, but also by brokers such as the model-strong consultants with strong influence on how the companies will have to implement the standards. If we consider the globalization and standardization of safety knowledge inevitable in the current political setting, then safety scientists need to consider what roles, if any, they want to seek in the development of standards and regulations and in their implementation. In some cases, safety scientists may be sufficiently familiar with the local context to make the standardization, adaptation, and implementation easier for the other actors. This local knowledge is not always manifested in the generalized models and theories, and it may be ignored and get lost if we leave it to the rest of the actors to generalize, standardize, regulate, and again adapt this knowledge into safe operations.

Argyris & Schön (1996:35-43) propose a view of practitioners as inquirers in their own right. According to this view, practitioners want to learn about causal connections between

organizational actions and outcomes in order to understand how organizations work and how they may be changed. They also seek to make sense of surprises and they often reflect on organizational practice. Practitioners even carry out experiments to gain new knowledge about their organization or sociotechnical system. There are, however, significant differences between the inquiry of practitioners and academic research as depicted by the conventional norms of rigorous scientific inquiry. Argyris & Schön (1983) propose "action research" as an approach to better integrate the knowledge of researchers and practitioners and to reduce the asymmetries of power produced when researchers provide practitioners with knowledge they can choose to adopt or not. They suggest that the researchers should "join with practitioners to help discover the hidden rationalities that are often built into everyday organizational practice, the productive forms of pattern causality of which practitioners themselves are often unaware" (p. 43). The researchers should help practitioners extend and enhance the inquiry they already know how to carry out, for instance by helping them discover how they get stuck and what dilemmas underlie their getting stuck, or how the same patterns of action that lead to success may also, on occasion, lead to failure. While action research may alleviate some of the power issues we address in this paper, it is also an approach that will tend to be local in nature, and only to a limited degree be able to challenge the surrounding framework of regulation, systems of accountability and standards.

6.6   Limitations and generalizability of the results

The empirical story we have told here is one about power and disempowerment of the practice field in the wake of sweeping trends of professionalization of safety management. We have described some developments in two Norwegian transport sectors that seem to be manifestations of broader societal and technological trends. The results cannot be generalized on a statistical basis. Rather, they invite a search for confirming cases as well as "counter cases" that may moderate our analysis. Moreover, as suggested by the analysis model (Figure 1), different effects may occur under different contingencies such as other societal trends or other intermediaries. However, the theoretical arguments are in principle applicable to other similar settings where intermediaries translate the results from safety science into standards and regulations and subsequently translate and adapt such knowledge to the local context. The phenomena of discursive power, model monopoly, and information asymmetry in principal-agent relationships could manifest themselves in a broad variety of circumstances. As a consequence, knowledge and power will remain interrelated.

7   Conclusion

The empirical examples presented in this paper show that the results of safety science do not necessarily have the form of neutral information when they reach the practitioners. In both cases, results from safety science were introduced as part of new safety management regimes. These regimes comprised new discourses on safety which challenged basic assumptions of the old regimes and made the more local or system-specific knowledge associated with the old

regimes peripheral, irrelevant or invalid. By redefining the domain of discourse, the new regimes created model monopolies where the representatives of the old regime emerged as model-weak actors. In the railway case, we also observed that main spokespersons of the old regime lost formal authority and positions of influence in their organization. In the maritime case, we observed that ship-owners who engaged consulting firms to develop safety management systems in accordance with the regulatory requirements experienced principal-agent problems because the ship-owners possessed limited information about the requirements to these systems. The new regimes may have contributed to significant improvements in risk management practices, but they may also have made the organisations involved less attentive to the safety concerns of representatives of the old regimes.

The disempowerment experienced by many practitioners and the marginalization of their safety knowledge is not a simple and direct effect of the knowledge produced by the safety science community. Rather, these effects are created in a constellation of (1) environmental contingencies such as new regulations and international standards and (2) intermediaries between safety scientists and practitioners, such as regulatory authorities and consultants. These constellations are influenced by more general societal trends, such as professionalization of the safety field and current demands for standardization and self-regulation through accountability-based systems.

The position of safety scientists in such processes is ambiguous. The search for broad generalizations and the widespread adoption of cybernetic thinking in safety science tends to resonate with trends towards standardization and bureaucratic control. The knowledge produced by safety scientists may be used in ways that the safety scientists did not intend and in settings they could not foresee. Safety scientists may, however, also be in a position to help practitioners challenge emerging model monopolies and thus enhance the diversity of sense-making with regard to risks. Safety scientists should therefore reflect on how the results they publish may interact with existing local and system-specific safety knowledge.

Acknowledgements

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