

EFFECTS OF TECHNOLOGICAL CHANGE ON SEAFARERS IN U.S. MERCHANT SHIPPING

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ABSTRACT: *This paper presents preliminary research on worker response to technological changes in the marine transportation industry, a capital and labor intensive service industry. These changes are analogous to those which constitute the manufacturing paradigm known as flexible specialization. Flexible specialization is the organization of production around automated or semiautomated machines able to turn out a variety of goods, while tended by a comparatively small cadre of workers who are there primarily as monitors. In general, the focus is on efficiency and cost reduction. Research on "flex-spec" has addressed not only the degree to which it is transforming the shop floor, but also the degree to which its principles are emerging in the service sector and the degree to which social and political factors affect technology adoption. This paper describes and discusses new navigation technologies and the associated changes in the marine workplace, such as the spatial reorganization of work and the hyperskilling of mariners. It then situates these changes within the existing literature on regulation theory and flexible specialization and argues that, in shipping, risk reduction has become a regulating social norm.*

INTRODUCTION

For the last two decades, and accelerating within the last ten years, a reorganization of the workplace has been underway in the world's merchant fleets, especially in northern Europe and in Japan, a reorganization made possible largely through advances in technology (NRC, 1990; Walton, 1987). As in other industries, economic pressures have spurred technological applications, especially toward crew reductions, though the need to reduce risk, to the ship and to the natural environment (this latter especially with the advent of supertankers) is a significant motivator as well. Technology, in fact, seems to resolve the contradiction between the apparently opposed goals of cost-reduction and risk-reduction. In this paper, in which I introduce the theoretical framework and some preliminary results of an ongoing project, I am particularly concerned with navigation, automation, and communications technologies in the U.S. merchant marine. Examining the changes precipitated by the Global Positioning System and Electronic Chart Display and Information Systems (a union of GPS and GIS) is significant for geographers, showing how

proliferating cartographic, positioning, and imaging technologies can affect the spatial and organizational distributions of work.

REGULATION THEORY AND FLEXIBLE SPECIALIZATION

This project relates bodies of work which so far have little linkage: that of regulation theory, and that of risk. Regulation theory attempts to explain productivity crisis and change in capitalist economies not through examination of market-driven equilibrating tendencies, but through examination of the social, political, and institutional structures which enable, constrain, or direct change (Jessop, 1995; Tickell and Peck, 1992). Regulationists reject "...the distinction between the economic and the extra-economic" and are interested in "integral economics"; i.e., the socially embedded, socially regularized nature of economic activities, organizations, and institutions" (Jessop, 1995: 309 citing Jessop, 1990: 6 and Jessop, 1992: 233-234). In this paper, I suggest that reducing risk has become an "extra-economic" factor in shipping: that is, a

factor which has economic consequences but which is not explicitly economic, influencing technology adoption, crew sizes, and other aspects of ship operations.

Regulation theorists typically consider several adaptive strategies used by industries to ease productivity crisis. A strategy that is particularly pertinent to this paper is the growth of a production paradigm known as "flexible specialization" (Schoenberger, 1988. See Christopherson, 1989 for a discussion on the service economy). Under a highly rationalized organization of production, machinery stock was geared to the manufacture of specific products in keeping with the demands of the semi-automatic assembly line. Shifts to new products or variations of existing products required an interval of slow and costly adaptation. The development of computer-control software enabled machine functions to change without expensive changes in design (Schoenberger, 1988). More importantly, a further result of the proliferation of Computer-Numerical Control (CNC) was the assignment of a single person to several machines, there to supervise and to intervene in the event of malfunction (Schoenberger, 1988: 253). Other strategies have been outsourcing, reliance on temporary or part-time workers, and internationalization of the labor market (Tickell and Peck, 1992; Schoenberger, 1988). Schoenberger (1988: 245) identified several categories of responses to competitive pressure in manufacturing: "shifting of production to low-cost areas overseas, the adoption of new manufacturing technologies and new ways of organizing production, the restructuring of supplier and subcontracting relationships" and others.

As a service industry, shipping is not subject to precisely the same range of pressures as is manufacturing; however, shipowners will find competitive advantage in responding to the cost-savings needs of manufacturers. For example, the urge to seek foreign sources of cheaper labor, now *de rigeur* in industrial restructuring strategy, has long had a seagoing parallel. Registering ships under a foreign flag, to take advantage of cheaper crews, cheaper inspection, and so on, has been practiced for generations; no surprise since, far more than shore-side manufacturing, shipping has always had an international dimension to its operations. If falling profits galvanized the manufacturing sector to restructuring, spillover effects flowed into shipping.

There is no mass production in shipping as there is in manufacturing, but there are analogs; for example, containerization gives an assembly-line quality to cargo operations, and at the same time, size generates vast economies of scale. Ships are built larger and larger because a large ship can carry cargo more cost-effectively than several small ships of equivalent aggregate tonnage, since the large ship requires only one engine plant and one crew.

The technological changes, and subsequent organizational changes, that have been emerging in shipping are directly analogous to those in manufacturing. Some of the first changes in shipboard organization began in the 1960s: the unattended engine room, for example, and the redesignation of unlicensed seamen as dual-purpose ratings (Walton, 1987; Mostert, 1974). More recently, the dual-trained navigation and engineering officer has become the multi-skilled worker demanded by the new doctrine of flexible specialization: one person in charge of several machines ("a monitor, not a doer," in the words of one shipmaster. "They want to dumb the job down so that the only thing for the guy to do up there [on the bridge] is make coffee."). In fact, the situation now has one person in charge of several departments, just as the worker in the flexibly-specialized plant monitors systems of machinery (Schoenberger, 1988: 253, citing Durand et al., 1984). Much ship's work is being outsourced, performed ashore by contractors, or even at sea, by "riding crews" which is in effect on site outsourcing with non-crew temporary workers. And soon, decision-support software will come aboard to relieve the cognitive burden of high-tempo ship operations, especially in navigation but probably elsewhere as well.¹

Risk and Work

As much as cost reduction, risk reduction has become a motivator for adoption of new technology, particularly following the public outcry after the grounding of *Exxon Valdez* in 1989. For example, the Oil Pollution Act of 1990, which mandated work-and-rest schedules aboard ship and extensive changes in ship construction standards, called for research and development of electronic charts. GPS and ECDIS are key among the emerging technologies which change work aboard ship, and which also have consequences for risk management.

An ECDIS is more than an electronic chart, just as a GIS is more than an electronic map. An ECDIS incorporates the real-time position information of the ship's GPS, the traffic detected by the ship's radars, and the hydrographic and topographic information contained in the electronic chart, and graphically displays these on a monitor. In theory, the complete navigation situation is available at a single location in the ship's pilothouse. Advances in computerized engine control systems enable all functions for conning the vessel to be brought to that single location as well, so that new ships' bridges have a cockpit-style arrangement as their focus, with one multi-skilled officer performing the jobs that had previously been done by the navigator, helmsman, lookout, and engineer. This uniting of the ship's control functions at a single station, replacing the hitherto dispersed arrangement of functions, is profoundly affecting the practice of navigation, and has ramifications which extend into such spheres as quality of work and safety (see NRC, 1990 and NRC, 1994). As NRC (1994) points out, the safety-enhancing potential of ECDIS is its streamlining of the navigation tasks. There is no more ricocheting to the bridge wing for a compass observation, to the radar to determine range to land, to the chart to plot the fix, back to the radar to evaluate the traffic situation, and so on. The practice of navigation is being altered to a series of tasks that operations engineers presume to be less error-inducing.

The reorganization is conjoined with a reorientation of skills and job responsibilities. In some countries, this reorientation has been underway for two decades, and is described in such works as Mostert (1974); Walton (1987); Roger (1983); Schrank (1983); NRC (1990); NRC (1994). Ship operators, with the encouragement and often the support of government, have achieved downsizing in two broad ways: 1) by employing "labor-saving" technologies to reduce numbers of crew, but with comparatively little change in seafarers' roles; and 2) by employing a panoply of computerized systems, in the engine room and on the bridge, which requires of seafarers a dramatically new mix of skills; revises job roles and relationships; and renders redundant half or more of seagoing jobs (see, for example, NRC, 1990; NRC, 1994; Walton, 1987). Ship operators are dissolving the formerly rigid distinction between the deck and engine departments, and are instead moving toward the "dual-skilling" of

mariners; that is, mariners are, or are expected to be, trained in both engineering and navigation/cargo operations. Thus, one officer can have charge of both the navigation and engineering functions of the vessel, since the engineering controls, more and more, are being brought to the bridge through computerization. Officers can perform maintenance tasks while off watch, thus allowing for further reductions in crew size. At the same time, mariners are required to undergo more and more training to allow them to operate the new equipment, a process I have termed *hyperskilling*: the need to accumulate an expanding range of skills to get or to keep a job.

The radio officer is an endangered species as well, by now. Due to the advent of the Global Marine Distress and Safety System (GMDSS), satellite communications, cellular phones, and fax machines (and two of everything for redundancy), the radio officer's arcane telegraphy and maintenance skills are presumed to be no longer needed. In time, perhaps, even the idea of separate "departments" may recede as mariners' jobs are blended. The situation may become analogous to that existing on sailing ships before the steam era, which were largely unidepartmental. While the radio officer is being phased out, the radio officer's work will remain to be done by the master or by the other officers, either while on watch, taking them away from navigation work, or off-watch, adding to overtime hours worked.

At the beginning of this paper I observed that technology is being used, by regulators, shipping companies, and some researchers, to resolve the contradiction between risk reduction and cost reduction. Typically, reducing risk appears expensive: new equipment must be added, new procedures followed, more stringent (and costly) standards must be met. The risk-cost relationship is different with seafarers: seafarers are regarded, by regulators, by industry, sometimes by themselves, as what Hilgartner (1992) calls "risk objects"--risky components of the marine transportation system--so the fewer of them the better, for both risk and cost. Regulators and operations researchers typically attribute about 80% of marine casualties to some manifestation of human error, so subordinating mariners to technology, or replacing them, seems to offer a good way of meeting shipping companies' need for reducing cost, and regulators' (and by extension, society's) need to reduce risk. This representation of mariners is not uncontested. Tasca

(1990) demonstrated how human error in the marine industry is "socially constructed" to suit the legal and administrative needs of shipping companies and the Coast Guard while Clarke (1992) described the political economy of risk and responsibility in shipping, in which certain rhetorics, including that of human error and that of the national energy interest, obscure the social contributors to disasters. Nevertheless the emphasis on human error (that is, on the risk of human failure) remains potent, and remains a significant justification for introducing new technologies, just as reducing cost is significant.

THE STUDY

In order to better understand the economic and extra-economic context of technology, risk, and navigation practice in merchant shipping, I am conducting a study of how mariners encounter and respond to technological changes. This paper presents a view of this ongoing project. It is primarily an ethnographic study, situated within the literatures of regulation theory and of risk. The primary methods are semi-structured interviews with mariners aboard ship, in union hiring halls, and in offices, and a mailed survey questionnaire. In the interviews, and in the questionnaire, I evaluate mariners' risk assessments and how new navigation and automation technologies affect those assessments. The project is ongoing, and while it is too early to draw definitive conclusions, some clear trends are evident. As individuals, and as a group, mariners have strong yet contradictory views of the new technologies that have been introduced into their workplace. They rely on the new tools yet caution that traditional skills should not be displaced by them. They appreciate the ease and convenience of the new tools, in particular GPS and Differential GPS (DGPS), and comment that the prompt position fixing allows them more time to "look out the window," a recurring phrase among the mariners I have encountered. The phrase refers, not just to looking outside, but to having a full appreciation for where the ship is and what is happening in the vicinity and to the exercise of traditional navigation practices. Mariners have commented on the confidence it gives them in difficult situations. One pilot wrote that DGPS

"eliminates stress like nothing else in my experience".

Others have reported that new technologies helped them successfully manage in potentially dangerous circumstances:

In poor visibility, I lost my radar in a turn while meeting a tug pushing a gasoline barge. DGPS got me through it.

I've had several situations where midway through a transit, the weather has dramatically worsened. The pilot-carried DGPS has been very valuable in those cases, providing precise navigation information that enabled me to complete the passage with a higher level of confidence and safety than by radar alone.

It seems clear that for some, these technologies are seen as conducive to reducing risk and improving the performance of mariners. However, others express concern that an over-emphasis on technology will distract the navigators from the "big picture," and thus divert their attention from looking out the window. One shipmaster remarked, "I was a big fan of slow computers. You could go out and look around while the computer worked." A ship's pilot wrote:

Today DGPS is accepted as correct and all other methods questionable...but GPS/DGPS is still only a *single* aid to navigation, and when it fails, people (pilots, captains) must retain the old and true/tried methods. In other words, the technology is great, but [you should] not allow a reduction in training and experience...If you do not look out the window, the machine will put you aground sooner or later.

Yet there is clearly a trend toward GPS and a subordination of other means of navigation. In this regard, Kasperson et al.'s (1988; see also Kasperson, 1992) theory of the *social amplification of risk* is particularly relevant. They find that the transmission and receipt of risk information is affected by several factors which amplify or attenuate risk, just as radio signals can be amplified or attenuated by intervening media. I suggest that navigation technology can serve as an attenuating factor within this conceptualization, which mariners are alert to and which they attempt to manage as a part of their professional practice. In conversation and in written responses to the mailed questionnaire, mariners stress that GPS and electronic charts are only aids to navigation: one source of navigational information to be consulted among many. The presence of technology can sometimes suppress the apprehension of risk. Poggie et al. (1995), in a study of risk

aboard New England fishing boats, found that sensation of risk was dulled by a faith in lifesaving equipment. Sometimes the result of that dulling can be an accident as in the grounding of the cruise ship *Royal Majesty*. In that accident, the ship's officers relied only on GPS, and as a consequence were unaware that its antenna was damaged and, therefore, giving faulty positioning information (NTSB, 1997). Human error certainly, but the technologization, and rationalization, of the navigator's duties promote reliance on GPS.

Some mariners observe that automation is fine until it breaks down. Then, systems which are designed to function automatically, or under remote control, become onerous to operate, especially with reduced crew sizes. Equipment that is normally automated is difficult to operate by hand, for example. An engineer commented:

It's hard work to turn valves manually that are meant to be operated automatically...Things are dispersed, so it needs more people to run things when something goes wrong. Someone has to be woken up, or maybe even two for safety.

And, some mariners are suspicious of the motives of the advocates of the new equipment. Another pilot wrote:

Here's a thought...this high-tech stuff is not so much at the request of navigators, but is for the shipowners to deflect blame and responsibility after an incident and/or to increase revenue by reducing manpower and/or sailing in unsafe conditions intentionally.

CONCLUSION

The "rhetoric of risk" (Clarke, 1992) is one of the regulating elements that determines or shapes the direction of this workplace/technological restructuring. Mariners must use the new technology, since the marine workplace and the demands of professional practice are being reconfigured around it, yet they are guarded in their assessments. The dissonance that emerges in seafarers' views of new technology stems from their contradictory relationships with it. Mariners must work with equipment which provides a rationale for eliminating their jobs or which they feel might circumscribe their professional autonomy. For example, the fleet

director of a shipping company said that maritime labor unions tend to obstruct adoption of new technology. He cited the resistance of shipmasters to the installation of transponders (devices which would identify the vessels to a "vessel traffic service" which assists in their navigation) because it might impinge on their authority. For mariners, however, distrust or wariness of new technology is justified by their experience. The accuracy of GPS, for example, may be an imperative for its use, yet over-reliance on it may lessen the more "artistic" skills that are necessary for verifying its proper functioning. As technology is introduced that does not accommodate traditional practices, mariners face a more drastic change in their work environment. Mariners who recognize these changes often distrust technology's role in reducing risk because they recognize technology's role in reducing the apparent relevance of traditional skills.

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NOTES

1. Schoenberger noted that productivity demands had "surpass(ed) the ability of humans to process information and to respond to events"(1988: 247). Researchers have observed that the demands on navigation in crowded waterways might present increasing perils. Grawbowski and Wallace (1993) and Grabowski and Sanborn (1995) have developed and tested a piloting expert system. This expert system assesses the navigational and traffic situation and provides analysis and guidance for pilots and watch officers.