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ARTICLE

Pride and mistrust? The association between maritime bridge crew officers' professional commitment and trust in autonomy

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Abstract
Increased automation and autonomy are anticipated in the maritime industry, and safe operation is contingent on operators' appropriate trust in the technology. Seafarers have a strong professional commitment, valuing practical experience and professional independence, which might be challenged by autonomous vessels. It was hypothesized that professional commitment would be negatively related to trust in autonomy and interaction with age of the officer. Using a questionnaire on bridge officers in Norwegian vessels ($N = 2016$), we performed a multiple linear regression to test the hypotheses. Professional commitment was significantly related to lower trust in autonomy, thus supporting this hypothesis. We found partial support for an interaction effect with age, as the effect of professional commitment was strongest among those with lower age. The model did not account for much variation in trust in autonomy and, therefore, seems to be largely related to aspects other than those considered in this study. Implications for future research are presented.

Keywords Trust · Automation · Autonomy · Professional commitment · Safety · Maritime · Navigation

1 Introduction

As the maritime industry increasingly adopts automated and autonomous systems, the nature of operating "smart" ships for maritime workers changes. As automation increases and manning is reduced, human-automation teaming is crucial for safe operation (Hult et al. 2019; Lee and See 2004; Nizar et al. 2023). One critical element of this teaming is seafarers' trust in automated systems (Lynch et al. 2022; Mallam et al. 2020). Seafarers trusting unsafe systems and

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distrusting safe systems may contribute to accidents with devastating human and environmental impacts (Parasuraman and Riley 1997). Unfortunately, the mechanisms that explain and promote trust in these novel systems are not yet fully understood, particularly considering that autonomous vessels are not in widespread operation and the maritime context consists of workers with a very high professional identity and strong traditions (Hult 2012). Some conceptualizations can be transferred from the domain of trust in automation, such as dispositional, situational, and learned trust (Hoff and Bashir 2015), whereas others argue that autonomous systems are distinctively different from automation. While automation refers to more or less well-defined tasks with deterministic results, autonomy refers to performing specific tasks independently while demonstrating human-like adaptive abilities using artificial intelligence (Xu 2020). Therefore, autonomy may include new and radical socio-technical configurations that call for new empirical and theoretical insights.

Most academic literature on autonomous vessels has focused on technological issues (Porathe 2022), and there have been efforts on other aspects, such as regulatory issues (e.g., Ahmed et al. 2023) and future competence needs (e.g., Emad and Ghosh 2023); however, in general, there is little research on human and organizational aspects (Hult et al. 2021). Speaking of trust in particular, research on social factors such as culture and identity is scarce (Hynnekleiv and Lützhöft 2021). Bearing this in mind, seafarers are noted for their strong belonging to their occupation (Hult 2012). A recent qualitative study (Aalberg et al. 2024) with 31 interviews shed some light on how seafarers develop trust in automated shipboard systems. The work was based on fieldwork on six state-of-the-art automated passenger vessels in Norway and indicated that several aspects of seafarers' trust in highly automated systems pertained to their professional identities. Importantly, however, they simultaneously exhibited low trust in their future autonomy. Therefore, in the present study, we focus on a specific element of the operators and their social system: the professional commitment of bridge officers. Since the technological changes to the industry imply radical changes to the seafaring profession, we hypothesized that the strong attachment, pride, and investment of maritime bridge officers in their work might be challenged by increased automation and autonomy. The overall research question was as follows:

How does seafarers' professional commitment relate to trust in autonomy?

This paper presents a large empirical study on maritime bridge officers' ($N = 2016$) trust in autonomy and professional commitment, seeking to contribute to reducing a significant research gap in the understanding of seafarers' views on the safety of increasingly autonomous maritime vessels. In the remainder of this paper, we first briefly describe the background of the research and theory to develop the hypotheses for our study. The "Methods" section describes the research procedures and instruments used. In the "Results" section, we present the results of the regression model predicting trust in autonomy based on professional commitment and age. Finally, the results are discussed considering previous research, followed by the conclusion and practical implications.

1.1 Trust in technology, automation, and autonomy

There are numerous definitions and understandings of trust as a phenomenon that stems from its multidisciplinary nature. Trust in technology can be understood as the belief that a specific technology has the attributes necessary to perform as expected in a given situation in which negative consequences are possible (Mayer et al. 1995).

According to McKnight et al. (2011), trusting technology depends on the mix of a generalized propensity to trust technology, trust in a specific technology, and institution-based trust in technology. The propensity to trust technology involves trust across different situations regardless of the type of technology. This signals trust in information technologies in general, and the use of such technologies leads to positive outcomes. Such generalized trust is necessary for the development of institution-based trust, involving a belief in the benevolence and integrity of system providers and that certain types of technology can be trusted in a specific context.

Trustworthiness consists of three dimensions; reliability, functionality and helpfulness (Mcknight et al. 2011). Reliability refers to whether a technology operates consistently and properly. Functionality refers to whether the technology can do what needs to be done, whereas helpfulness concerns whether the technology provides adequate and responsive assistance. Hynnekleiv and Lützhöft (2021) claimed that trustworthiness is a phenomenon that relates to the system itself, whereas trust is the subjective belief of the operator.

Technological systems with increasing independence from human operators are somewhat different from simpler systems. Therefore, trust in automation has arisen as a dedicated research field (Hoff and Bashir 2015; Lee and See 2004). Based on Castaldo et al. (2010), we consider trust in automation as the belief from a trustor that an automated system will produce positive results in situations of perceived risk and vulnerability. Trust influences when and whether users decide to use automation and has an overall effect on the reliability, efficiency, and safety of sociotechnical systems (Hoff and Bashir 2015). In terms of safety management, one should aim for the appropriate trust in fallible systems. Appropriate trust, or critical trust (Lee and See 2004), can be understood as a correlation between subjective trust and the trustworthiness of the system (Hynnekleiv and Lützhöft 2021).

Hoff and Bashir (2015) proposed a three-layer framework to indicate the variability of trust in automation. Dispositional trust refers to the foundational tendency toward trust automation and consists of aspects such as culture, age, and personality traits. They are longitudinal tendencies, both from internal and external origins. Situational trust highlights context-specific human-automation interaction, along with its environmental and operator characteristics, and thus separates internal and external variability. Examples of such characteristics are workload, perception of risk, self-trust, and the complexity of the system. Learned trust concerns the trust that forms through familiarization and experiencing the system and relates to factors such as the reputation of the system and previous experiences with similar systems. Thus, there are three sources of variability in trust in automation: operator, automated system, and environment.

Several scholars have pointed out that trust in maritime autonomy is crucial for adoption and safe operations; however, research on this topic is scarce. Hynnekleiv and Lützhöft (2021) reviewed trust issues in autonomous maritime operations and presented three meta-categories of trust: (i) technology acceptance, (ii) operational trust, and (iii) trustworthiness. Technology acceptance comprises generalized trust, trust from society, and the perceived level of safety. Operational trust encompasses dispositional trust, transparency, human-automation teaming, and language and culture. Finally, trustworthiness was specifically oriented towards the reliability of the system and the explainability of what it is doing. Considering the latter, others have also pointed out that trust in maritime automation technology is dependent on ensuring a system that can communicate its decision-making (Alsos et al. 2022; Mallam et al. 2020), to have an explainable artificial intelligence.

Hult et al. (2021) surveyed Swedish seafarers (N = 1185) and found that seafarers scored high on professional commitment and low on motivation for working onshore[1], which might be considered a potential scenario for the future. They also found that seafarers were generally negative towards the safety of increased digitalization and reduced manning on vessels. However, this study did not use bivariate or multivariate techniques to explore the potential association between professional commitment and trust in autonomy. Therefore, we will now turn to professional commitment as a concept and why it could be relevant for trusting such technologies as a form of dispositional trust.

1.2 Professional commitment and trust

First, a brief discussion of the concept of the profession is required. Cohen (2003) pinpointed the confusion around related terms for work such as profession, career, and vocational, arguing that most of these are used interchangeably in the literature. Meyer et al. (1993) also address this issue and propose that "occupation" is a unifying term. Kerr et al. (1977) argued that expertise, autonomy, identification, and the ethical and collegial maintenance of standards define a profession. Maritime occupations might not be considered professions based on the stringent understandings provided by Abbott (1988), e.g., that a profession has state-sanctioned control over the acquisition of knowledge. In the maritime industry, the boundaries are not so clear-cut. The strong commitment, identification, expertise, and strong norms of behavior associated with maritime officers make the theoretical perspective of the profession helpful. Therefore, professional commitment was used in this study.

Professional commitment is a central element of work and education within professions such as healthcare and education. It pertains to the emotional bond with the occupation and how strongly one identifies with the profession's values and goals (Nesje 2017). Put simply, one could describe professional commitment as "one's attitude towards one's profession" (Blau 1985, p. 285). Professional commitment can be seen as foregrounding professional identity development (Muslu 2022). Employees' commitment to their profession has been associated with how they behave on the job, even when controlling for organizational commitment (Meyer et al. 1993).

[1] It is important to note that while autonomous ships might sail autonomous, there will likely be a need for personnel on board, especially as a safety manning on passenger ships (Holte and Wennersberg 2023)

Meyer et al. (1993) proposed a multi-dimensional three-component model of commitment (to organization, occupation, and profession) that together characterizes the relationship between the worker and the work. The first dimension is affective attachment, which concerns the emotional attachment to an occupation. Second, continuance commitment refers to the perceived cost of leaving the occupation, that is, they need to stay for certain reasons. Third, normative commitment pertains to a feeling of subjective obligation to remain in an organization. Similarly, Morrow (1983) argued for three dimensions: (1) a general attitude, which concerns the extent to which one considers work as life; (2) professional planning thought, which concerns that the individual develops long-term career plans; and (3) the relative importance of the profession, which is the relative preference for professional and non-professional activities. To summarize, both argue for an emotional bond with occupation as a main aspect and how it intertwines with their lives outside the occupation.

Hult (2012) provided an overview of factors that have been found to contribute to professional motivation or commitment: (i) independence in the work, (ii) social aspects, leadership, and work-home relationship, (iii) work satisfaction, and (iv) age, years invested in the occupation, and the length of education.

Many studies have been conducted on professional commitment in health and education research, but less in the maritime profession, which is of course interesting, as seafarers score very high on professional commitment (Hult 2012). Professional commitment for seafarers is influenced by the fact that working on a ship involves some level of physical and psychological isolation, is sometimes perilous in terms of accidents, and has significant environmental, physical, and social implications for seafarers.

High professional commitment is also associated with higher board safety. Muslu (2022) argued that professional commitment is important for safety because it hinders safety management problems of high turnover and could reduce human error. Moreover, professional commitment acts as a buffer for employees against high demands and negative events.

A profession with a common identity and purpose continuously shapes the values tied to their work, and a person with high professional commitment internalizes such values with their own identity so that they are inextricably linked (Muslu 2022). Understanding professional culture and identity is important for understanding informal rules regarding work practices and decisions (Antonsen and Bye 2015). Moreover, it is likely that such references play a role in determining attitudes and behavior in relation to technology embedded in core tasks and operations. Whether technology is trusted depends on whether it is regarded as an extension of expertise or, in contrast, perceived as diminishing performance or a threat to sociocultural traditions. Therefore, strong professional commitment can amplify attitudes towards technology entities, either positively or negatively.

Drawing on some key elements in theory and previous research, we suggest that the association between professional commitment and trust in autonomy is negative. Professional independence is an inherent feature of a profession that exhibits strong identities as it can be considered an outcome of identity formation (Teng 2019). Technology has been found to challenge these notions because professionals are increasingly dependent on digital and automated systems in their work (Charatsari et al. 2022). Indeed, Hult (2012) found in their study that job content is important for professional commitment and that autonomy (sic) is one of the attributes that were both regarded as high in importance and being at a satisfactory level; thus, one can assume that seafarers might be worried about losing their professional autonomy due to technological autonomy. For the captain of a ship, automating a central task such as navigating a ship involves the probability of feeling less independent and "in control."

Studies have shown that seafarers are reluctant to trust other formal entities that guide or control work, such as procedures or safety management systems, leading to identity crises (Anand, 2011; Knudsen, 2009). In the aforementioned qualitative fieldwork, the Aalberg et al. (2024) found that seafarers exhibited distrust towards the safety of future autonomous systems due to a perceived lack of emergency preparedness capacities, lack of "seamanship" abilities and perceiving human decision-making as more "holistic," and partly due to the perceived challenge it involves for their professional independence.

In summary, our main hypothesis is as follows:

H1: There is a negative relationship between professional commitment and trust in autonomy

Here, we understand that high professional commitment might be seen as a specific type of dispositional trust that increases mistrust in autonomy as an entity.

1.3 Age of operator and trust

Older seafarers exhibit high pride in their occupation and have developed over the years as maritime officers (Hult 2012). Age is one of the elements that has been investigated in terms of maritime automation. Chan et al. (2022) found that older and younger officers ($N = 100$) had a similar outlook on autonomy: they were receptive towards automation but were skeptical about the issues of responsibility and safety in the scenarios of unmanned vessels. This was surprising, considering that research in the aviation sector has demonstrated that older pilots are more worried about overreliance on automated systems, whereas younger pilots are more receptive towards automation (Koltai et al. 2014; Taylor and Cotter 2018). Palbar Misas et al. (2022), however, found that younger navigators were more inclined to trust digital systems. They attributed this to the higher reliance on digital aids promoted through training. Hence, there remain open questions regarding the relationship between age and trust in automation. In their review of the factors influencing automation trust, Hoff and Bashir (2015) considered the issue unresolved. Considering the accumulated research field of trust in technology as a whole, we believe it is probable that older seafarers exhibit lower trust in increased automation. This leads to the following hypothesis:

H2: There is a negative relationship between age and trust in autonomy

This implies that the older the seafarers, the less they trust autonomy.

Adding to the complexity, the Aalberg et al., (2024) found that several younger crew members on passenger ferries exhibited a strong professional commitment

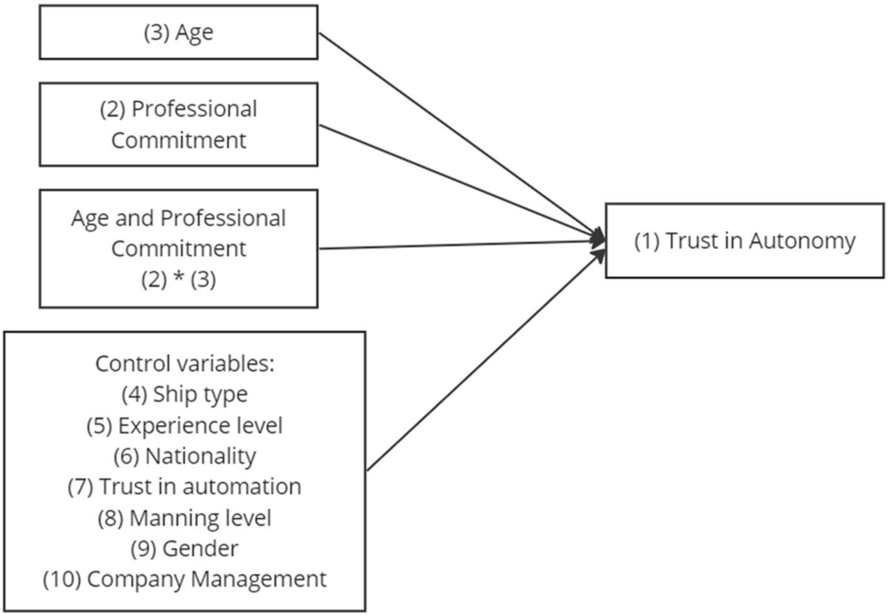

Fig. 1 Statistical diagram of the regression model in the present study

and, at the same time, exhibited a general positive attitude towards new technology. This was in contrast to the fact that older personnel, who also exhibited a strong commitment, were more skeptical of new technology. As an implication, we explore the notion that the relationship between professional commitment and trust in autonomy interacts with age.

H3: There is an interaction effect between professional commitment and age on the relationship with trust in autonomy

This implies that the association between professional commitment and trust in autonomy is at least partially contingent on the seafarer's age.

In addition to these variables, which have a theoretical and empirical basis for a specific hypothesis, additional variables were added: trust in (existing) automation, experience level, manning level, company management, and ship type. These variables were also deemed potentially relevant for trusting autonomy. The rationale for including each variable is provided in Sect. 2.1 along with a description of the measure. The model used for the analysis is shown in Fig. 1.

2 Methods

In this section, descriptions of the procedures, samples, instruments, analyses, and ethical considerations are provided.

2.1 Survey

The survey “Safety Perception on Norwegian Vessels” (SPIN-V) contains 160 questions (average time for completion: 27 min) relating to the maritime professionals’ perceptions of safety climate, work environment, work conditions, and technical conditions on the ship. Previously, the questionnaire underwent preliminary validation, indicating satisfactory validity and reliability (Aalberg et al., 2020; Kongsvik and Aalberg, 2022). The survey was developed based on several industry-specific safety climate surveys (Aalberg et al., 2020; Kines et al. 2011), in combination with a conceptual risk model of Norwegian waters (Haugen et al. 2016), through a process involving researchers, subject experts, authorities, and trade unions. In 2023, along with other constructs, new items were added to measure professional commitment, trust in automation, and trust in autonomy.

2.2 Instruments

This study has three main variables and seven control variables, as described in the following sections.

2.2.1 Dependent variable: trust in autonomy (1)

The dependent variable is a new two-item aggregate measure measured on a Likert scale from 1 = “completely disagree” to 5 = “completely agree.” This demonstrates satisfactory reliability ($\alpha = .73$). Trust in autonomy contained the following two statements: “I believe that autonomous vessels will make seafaring safer” and “Increased automation on board will contribute positively to safety,” introduced with a help text that briefly explains the context of these statements. The factor loadings for this variable were both approximately .87.

Considering this research gap, there is no consensus on the specific aspects or items to be included in such a construct. The items were developed through a workshop with a researcher, two experts in autonomy from the Norwegian Maritime Authority, and one industry expert in questionnaire research based on an initial scale developed by Hult et al. (2019). It was then piloted for feedback by various stakeholders before determining the exact phrase. Considering the understanding of trust in automation as a belief from a trustor that an automated system will produce positive results in situations of perceived risk and vulnerability, based on Castaldo et al. (2010), we believe that these two statements adequately address the main aspects of the definition of trust, specifically a subjective belief in the safety of the system. Bearing in mind the future-oriented and uncertain nature of the phenomenon of autonomy, we believe that it makes sense to address the question more generalized, as it would be difficult for the respondent to distinguish the dimensions in a situation of limited information availability. Thus, the instrument is a global impression that can be captured with a few items (Körber 2019). However, this is at a cost, considering that we do not know which aspects of trust are the basis of the response, for example, whether it is due to the perceived reliability, functionality, or helpfulness of the system.

2.2.2 Professional commitment (2)

Professional commitment was measured using a three-item scale (α = .80). It measures the attitudes they exhibit towards the profession, for example, "The seafaring profession is a part of my identity." Factor loadings ranged from .76 to .86 and were treated as continuous in some of the analyses. For the sake of brevity, the scales in the present study on professional commitment primarily concern the affective dimension of Meyer et al.'s (1993) model. Lu et al. (2007) have developed a popular professional commitment scale originally for nursing; however, it has not been applied to the maritime sector to a large degree, let alone Nordic populations. Therefore, we adapted the scale developed by Hult (2012), which was applied to over 1300 Swedish seafarers. They found a three-factor structure that discriminated between occupational (professional) commitment, organizational commitment, and employment commitment. They found five items to "occupational commitment," where we selected the three items with the highest factor loadings (0.74–0.86) for the purpose of our study.

2.2.3 Age (3)

Age was measured on an ordinal level with 5 categories, where 1 = "younger than 26 years," 2 = "26–35 years," 3 = "36–45" years, 4 = "46–55" years, and 5 = "56 years and more." There is debate on how to treat age as a variable (Andrade 2017), and research has applied both age as a categorical and continuous variable. We interpolated categories into a continuous variable by transforming them into approximate age, as demonstrated in Table 1, as a measure against heteroskedasticity, and for easier interpretation of interaction effects. This rests on the assumption that age is normally distributed in the population.

2.2.4 Ship type (4)

The type of ship or vessel on which the respondent worked was included as a control variable for several reasons. First, the type of ship strongly implicates variations in

Table 1 Conversion of age as a category into a continuous variable

Age category	Transformed to continuous age
Younger than 26 years	25 years
26–35 years	30.5 years
36–45 years	40.5 years
46–55 years	50.5 years
56 years and more	56 years

operation and, specifically, workload, thus potentially implicating trust (Mcknight et al. 2011). Moreover, for some ship types, especially smaller passenger and cargo vessels, ship autonomy is more imminent than for others (Hult et al. 2019), and might therefore reflect familiarity with technology or job insecurity. We used a taxonomy developed in the National Ship Risk Model Project (Haugen et al. 2016) to distinguish vessels within cargo, passengers, and fishing. Cargo ships were used as the reference category.

2.2.5 Experience level (5)

Considering the close relationship between experience level and age, we controlled for experience level to determine whether a potential effect in the multivariate model could be attributed to one or both. Additionally, subject matter expertise has been seen in relation to not relying on automation (Hoff and Bashir 2015), which could be associated with a seafarer's level of experience. Experience level was measured using an ordinal scale with six levels, from 1 = "0–5 years" and a 5-year interval until 6 = "26 years or more." 0–5 years was used as reference category.

2.2.6 Nationality (6)

The nationality of the respondents was included to control for potential cultural differences in the propensity to trust, especially considering that Norwegian society has a high level of institutional trust (Wollebæk et al. 2012). The variable was dichotomized as 0 = "Norwegian" and 1 = "international."

2.2.7 Trust in automation (7)

Trust in automation was adopted by Li et al. (2022), who developed a battery based on the theoretical considerations of Körber (2019). It consists of four items pertaining to existing shipboard systems: reliability, propensity to trust, predictability, and general trust in the system. Most of these systems today are not advanced and are distinctively different from future autonomous systems. It was measured on a scale from 1 = "completely disagree" to 5 = "completely agree" and consisted of items like "I can rely on the automated shipboard systems". Cronbach's alpha was good (α = .91). Factor loadings were .71 to .82, and the factor was used in analyses as continuous.

2.2.8 Manning level (8)

Considering the evident potential issue pertaining to manning in the case of increased automation, we wanted to control for the perceived adequacy of manning today. This factor was measured on a Likert scale from 1 ("completely disagree" to 5 = "completely agree," with items such as "the manning onboard is sufficient to ensure safety" (α = .79). Factor loadings ranged from .5 to .74 and were applied as a continuous variable of the analyses.

2.2.9 Gender (9)

The use of gender as a sociodemographic factor in regression models is widespread. Specifically, some research has shown that gender potentially plays a role in trust, but consistent differences have not yet surfaced (Hoff and Bashir 2015). Gender contained responses to “male,” “female,” “other,” and “do not wish to answer.” It was coded binary as 0 = male and 1 = female.

2.2.10 Company management (10)

Company management is a factor in safety climate research that concerns how seafarers value and perceive onshore management (Aalberg et al., 2020). It was included considering that the implementation of automation can be considered to indicate a lack of trust in management and that manning conflicts are often between onshore management and the crew. It consists of six items, such as “To follow safety procedures is not valued in the company I work for” measured on a Likert scale from 1 = completely disagree to 5 = completely agree. Cronbach’s alpha (α) was .83, and the factor loadings ranged from .55 to .74.

2.3 Procedure

The survey was administered bi-annually to seafarers on Norwegian ships through e-mail links to an online questionnaire (Netigate) with up to five reminders. In 2023, it was distributed from 09.01.2023 to 20.02.2023 and got $N = 8391$ answers. Based on an estimation of 47,635 seafarers (Pytte and Sørskår 2023), responses were obtained for 17.5% of the total population. To reach seafarers, e-mail lists were obtained from nine actors, including shipping companies, unions, federations, and official authorities. A total of 34,023 unique e-mail addresses were identified and distributed, which equaled a response rate of approximately 25%. This also entails 1000 fishers that were interviewed on a phone with a selected subsample of the questionnaire. The response rate is tangent to similar industry safety climate questionnaires such as the Norwegian Petroleum Authority NORSCI (Kines et al. 2011). Based on the estimated population sizes across vessel types (Pytte and Sørskår 2023), error margin calculations at the 5% level were considered. The margins ranged from 1.0 to 5.2% across the various vessel types, except for small passenger vessels, which had an estimated error margin of 9.1%. Seafarers on small passenger vessels account for only approximately 6% of the total population of seafarers; therefore, we consider this sample bias to have a minimal impact on the validity of the findings.

2.4 Sample

The sample for the present study was a subset of the survey, consisting of personnel working on the ship bridge, that is, officers whose tasks are mainly navigation, watchkeeping, and steering of the ship. We excluded respondents from naval ships (categories with low *N*) and petroleum rigs. Excluding incomplete responses, the number of respondents included in the analysis was $N = 2016$ (approximately 37% of valid responses). Unfortunately, population estimates of the proportion of seafarers working on the bridge are not available; therefore, a quantified estimation of the error margin for subsample representativity is not possible.

The characteristics of the sample are listed in Table 2. The low number of women in our sample (approximately 2.4%) was unsurprising. A recent report showed that approximately 11% of the seafarers in Norway are women (Wold et al. 2022). The proportion of women found by Wold et al. is likely to be considerably lower for bridge crews, since their estimation included traditional positions dominated by women, such as catering crews. In fact, the bridge is perhaps one of the departments with the least number of women, which is illustrated by the fact that female captains are a novelty even in large shipping companies (e.g., Stena Line 2022).

Table 2 Sample characteristics ($N = 2016$)

Variables and levels (variable no.)	Freq.	Percent
Ship type (4)		
Cargo ships	1195	59.28
Passenger ships	624	30.95
Fishing vessels	197	9.77
Nationality (5)		
Norwegian	1789	88.74
International	227	11.26
Years of experience (6)		
0–5 years	172	8.53
6–10 years	290	14.38
11–15 years	291	14.43
16–20 years	276	13.69
21–25 years	272	13.49
26 or more years	715	35.47
Gender (9)		
Male	1967	97.57
Female	49	2.43
Age (3)		
Under 26 years	122	6.05
26–35 years	445	22.07
36–45 years	451	22.37
46–55 years	553	27.43
Over 56 years	445	22.07

2.5 Analysis

The primary analysis consisted of a multivariate regression model performed using STATA/MP version 17.0 along with various tests for technical assumptions. Generally, considering that the research is oriented towards understanding the relationships between complex social phenomena, regression analysis is an adequate statistical method (Mehmetoglu and Jakobsen 2022). This is primarily because it indicates the strength, direction, and form of the relationship between variables and allows for the control of variations in other variables.

The continuous variables included in the analysis, along with other items in the questionnaire, were subjected to iterations of principal component analysis (PCA). The determination of the factor structure was based on a combination of Kaiser's criteria, scree plot inspection, theoretical guidance to determine the factor structure, and reliability analyses (Cronbach's alpha).

2.6 Ethical considerations

The respondents were asked for informed consent to voluntarily participate in the study and were provided with the opportunity to retract their participation. Data were anonymized by the data processor prior to analysis, treated confidentially, and in accordance with the data protection laws. The research project's ethics were notified and approved by the governing regulatory instance National Centre for Research Data AS, protocol number 948264, dated 17.04.2022. The data processor was Safetec Nordic AS on behalf of the Norwegian Maritime Authority (NMA).

3 Results

In the following section, we describe the general descriptive statistics and the results of the regression model.

Descriptive statistics for continuous variables are presented in Table 3. Trust in autonomy scored low (M = 2.19, SD = 1.02), indicating low trust exhibited by bridge crew officers, albeit with considerable variation. On the other hand, professional commitment scored very high (M = 4.67, SD = .77), indicating

Table 3 Descriptive statistics for continuous variables (N = 2016)

Variables	Min	Max	Median	Mean	SD
Trust in autonomy (1)	1.00	5.00	2.00	2.19	1.02
Trust in automation (6)	1.00	5.00	4.00	4.08	.86
Professional commitment (2)	1.00	5.00	4.67	4.45	.77
Company management (10)	1.00	5.00	3.75	3.51	1.2
Manning level (8)	1.00	5.00	3.83	3.65	.95

high engagement and emotional bond to their occupation. Trust in automation, as opposed to trust in autonomy, also scored higher, with a mean of 4.08 (SD = 1.86).

In the following, the technical assumptions of regression modeling are presented, followed by the results from a multiple regression model predicting trust in autonomy.

Perhaps the most intuitive assumption of linear regression is that the regression curve should be a straight line, that is, linear (Field 2009). This was tested using Ramsey's regression equation specification error test (RESET) and the Linktest (Pregibon 1980), both of which indicated linearity.

To validate the model, it is important to adequately investigate the residuals (error terms) (Mehmetoglu and Jakobsen 2022). The Breusch-Pagan test for heteroskedasticity was significant ($X^2 = 31.34$, $p < .001$), indicating heteroskedasticity, but was improved by the logarithmic transformation of the dependent variable and transforming age to continuous ($X^2 = .18$, $p = .67$). There should be no correlation between the residuals and independent variables in the regression (Mehmetoglu and Jakobsen 2022) which was confirmed. A histogram with a fitted normal curve of the residuals showed some signs of normality, but a positive skew, and was slightly bimodal. Therefore, we tested a model with a dichotomous dependent variable, trust in autonomy (0 = below the mean and 1 = above the mean). The results were more or less identical to those of the linear model. Thus, we chose to retain the linear model, especially considering that the assumption of normality is not considered important for linear regression (Skog 2004), dichotomizing leads to data loss (Altman and Royston 2006), and trust as a phenomenon exists on a continuum rather than classifications (Pidgeon et al. 2010).

Additionally, multicollinearity was assessed with a variation inflation factor, where no variables were over the cut-off value of 10 (mean = 3.59) or tolerance lower than 0.1. Finally, we checked for high leverage (influential points) using *lvfrplot,* and no leverage was above .03, well within the criteria of 0.2 (Mehmetoglu and Jakobsen 2022).

Table 4 presents the log-linear regression model. The model accounted for a low amount of variance in trust in autonomy ($F = 12.26$, $R^{2\text{adj}} = .08$). We found that professional commitment was significantly related to trust in autonomy ($B = -.19$, $p < .01$), supporting hypothesis 1. In a log-linear regression, the coefficients are proportional, and a one-unit change in X equals a % change in Y based on Euler's number. This means that for each point increase in professional commitment, the trust in autonomy score decreases by approximately 21%[2]. Note that this is given by age = 0 because of the interaction term.

Age was found to be insignificant in this model ($B = -0.05$, $p > .05$). Moreover, the interaction term between age and professional commitment was insignificant; therefore, we initially retained the null hypothesis for hypotheses 2 and 3. However, for hypothesis 3 (the interaction), as noted by Brambor et al. (2006), one is not directly interested in the significance level but in the marginal effects of the predictor on the outcome considering the multiplicative variable. As shown in Fig. 2,

[2] $100^* (e^B - 1) = 100^* (2.7182^{0.19} - 1) = 20.92\%$

Table 4 Summarized results from log-linear regression ($N = 2016$) predicting logarithm of trust in autonomy

Variables (variable no.)	B	SE
Ship type (reference category: cargo ships) (4)		
Passenger vessels	−0.03	0.03
Fishing vessels	0.03	0.04
Gender (0 = male, 1 = female) (9)	−0.10	0.07
Age[a] (3)	−0.01	0.01
Experience (reference category: 0–5 years) (5)		
6–10 years	0.10**	0.05
11–15 years	0.02	0.05
16–20 years	0.03	0.05
21–25 years	−0.02	0.06
26 or more years	−0.06	0.06
Nationality (0 = Norwegian, 1 = international) (6)	0.14***	0.03
Professional commitment (2)	−0.19***	0.06
Trust in automation (7)	0.05***	0.01
Company management (10)	0.05***	0.01
Manning level (8)	0.02	0.01
Age (3) × professional commitment (2)	0.00	0.00
Constant	1.06***	0.26
Observations	2,016	
Adjusted R-squared	.08	
F-stat	12.26	
Prob > F	0	
Degree of freedom	2000	

***$p < 0.01$

**$p < 0.05$

[a]Age was measured at an ordinal level and interpolated into continuous variables, as described in Sect. 2.2.3

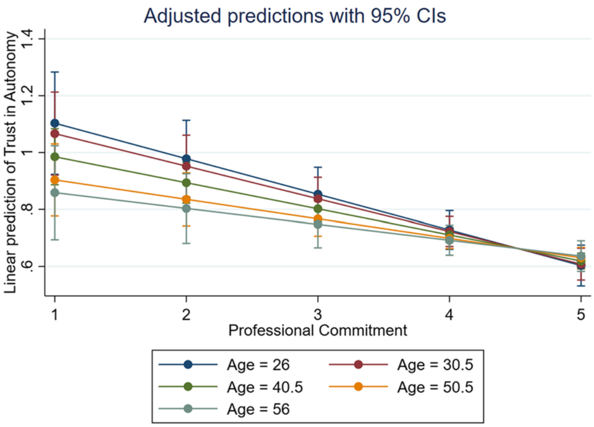

Fig. 2 Marginal effects of professional commitment on the logarithm of trust in autonomy for ages 26–56 (interpolated)

higher professional commitment was associated with lower trust in autonomy; however, the slope was steeper for younger bridge officers than for older officers. The highest and lowest predictions of trust in autonomy were related to younger bridge officers. This implies that the magnitude of the effect of professional commitment on trust in autonomy is conditional on age. Therefore, these effects yield partial support for hypothesis 3.

Trust in automation and company management were positively related to trust in autonomy, although the effect sizes were low ($B = 0.05$, $p < .01$). International respondents were more likely to respond more positively to trust in autonomy than Norwegian respondents ($B = 0.14$, $p < .01$), and seafarers with 6–10 years more likely to answer positively than those with less experience ($B = 0.10$, $p < .05$). Ship type and manning level were not significantly related to trust in autonomy.

4 Discussion

In this study, we were primarily interested in how seafarers' professional commitment relates to their trust in the safety of increased ship autonomy, which is discussed first, followed by hypotheses 2 and 3 (age and interaction effects). Subsequently, the model as a whole is discussed, and future research considerations are made.

4.1 Hypothesis 1: professional commitment

Seafarers exhibited high professional commitment and low trust in the safety of autonomous ships, which is consistent with the findings of Hult et al. (2021). These phenomena were significantly related, thus supporting hypothesis 1. This implies that attitudes towards the profession (i.e., professional commitment) are associated with attitudes towards whether increased automation contributes to safety (i.e., trust in autonomy).

Considering previous research, a likely explanation for this effect is that increased automation might represent significant tensions with aspects that traditional seafarers value as part of their profession, such as independence (Kongsvik et al., 2020), practical work, and experience at sea (Bye & Aalberg, 2020). Increased automation might challenge the perception of who is in "control" versus simply being an extra tool and reducing the practical core task of actually operating a ship (Aalberg et al. (2024). For officers, ship autonomy can be perceived as having excessive agentive power, challenging their job control. Therefore, it also reduces independence, which is an antecedent of professional commitment (Hult 2012). Hypothetically, if the degree of human involvement and perceived control would be at status quo, one could speculate that trust in autonomy would be higher.

The relationship might also indicate perceived job insecurity or negative affirmation of the notions of lower manning or associating autonomy with work onshore (Hult et al. 2021). However, job insecurity is not a prominent concern for students and officers working on bridges (Bogusławski et al. 2022). Further, if job security was a strong determinant, we would expect to see significant differences between ship types, perceived adequacy of manning level, and perception of company management, which was not the case. Further research should include variables that measure job insecurity to support these findings.

4.2 Hypotheses 2 and 3: age and professional commitment

When controlling for other variables, maritime officers' age was not significantly related to trust in autonomy and provided no support for hypothesis 2. This was surprising considering previous research (Taylor and Cotter 2018). This implies that seafarers' age does not have a causal or associated relationship with whether they have a positive belief in the safety of future autonomy. However, bridge officers' with 6–10 years of experience scored significantly higher than those with less experience.

However, the interaction effect of age and professional commitment concerning hypothesis 3 was partially supported. Despite the insignificance, the marginal effects showed that there was some effect of professional commitment on trust in autonomy that was conditionally related to age. As previously noted, marginal effects may be more relevant than significance (Brambor et al. 2006). The negative slope of trust in autonomy, when professional commitment increased, was less steep for older bridge officers. Those who reported the highest and lowest trust were both younger generations, but what separated them was their degree of professional commitment (high and low, respectively). This means that the effect of professional commitment on trust autonomy is partially dependent on age (or vice versa). There are several potential reasons for this.

First, it could be related to continuance commitment and perceived cost of leaving the profession (Meyer et al. 1993). For older personnel, their professional commitment might not be as influential on trusting (future) autonomy because of their more imminent retirement, whereas for younger personnel, with their career in front of them, commitment and attachment to their work are relatively more impactful.

Another reason could be that younger personnel have a better understanding of the implications of technology through higher digital literacy. Through their professional commitment, they invest effort in technological competence and participate in projects concerning technological developments, which allow them to trust or distrust based on better information and competence levels. On the contrary, one could infer that older workers are more negative due to their experience and deep knowledge and that professional commitment is less important than that.

Although there were signs of an interaction effect, it was not significant. First, although we did not find multicollinearity issues, experience level or professional commitment could cancel the effect of age to some degree. The operationalization of age in ordinal categories has reduced statistical power, that is, the probability of discovering an existing effect in the population in the significance test. It could also be problematic to use age on an ordinal level as continuous, as it assumes a normal distribution and is sensitive to the exact transformations. The interpolation of age contributed to an enhanced model (reducing heteroscedasticity), but it is debatable whether this is a valid transformation. To further explore the effect of age on trust in autonomy, it is advisable to measure age continuously.

4.3 Overall model and future research considerations on trust in autonomy

There were four significant predictors in the model in addition to professional commitment, including company management, nationality, trust in automation, and experience level; however, all had low effect sizes. Company management was significantly related to the outcome, but the effect size was very low (B = .05). This means that perceiving a shipping company's emphasis on safety has a minimal but positive effect on trust in the safety of autonomy. Regarding nationality, international bridge officers scored slightly higher on trust in autonomy than Norwegian officers. This finding is interesting and might show that national culture has an influence on the level of trust. It can also imply that the perception of job insecurity differs, or simply that international officers have less preexisting knowledge of and exposure to autonomy development due to less access to Norwegian discourse on autonomy in the industry and media. Officers with experience level of 6–10 years score somewhat higher than those with less experience. This finding can be seen in relation to the discussion on age (Sect. 4.2.) Finally, although significant, the association between trust in automation and trust in autonomy was surprisingly low (B = .05). This finding yields little support for a spillover learned trust (Hoff and Bashir 2015) from automation to autonomy and supports that autonomy is perceived as distinctively different from automation (W. Xu 2020).

Despite significant findings on specific predictors, such as professional commitment, trust in autonomy remained largely unexplained by the present variables (approximately 8%). It is important to emphasize that the low explained variance does not negate the importance of the individual effect of professional commitment: Professional commitment contributes significantly to the level of trust in autonomy on average, but there is considerable variability in trust in autonomy that is unexplained. This means that for individual respondents, there are major uncertainties in predicting their level of trust in autonomy, let alone the reasons for their scores.

There are several potential explanations for the low variance. First, an evident explanation is the lack of the included variables. Future research could also consider implementing more questions on other aspects of trust in autonomy, such as discriminating between the reliability and functionality of the trustworthiness of the systems. For example, this could be a general propensity to trust the technology or the trustworthiness of the technology involved (Hoff and Bashir 2015; Mcknight et al. 2011). Knowledge of or familiarity with these novel technologies and the general perceived risk level might also influence trust and could also include a moderator variable that indicates familiarity with the technology (Körber 2019). There are also other potential influencing factors of trust pertaining to situational variation, such as the level of risk, workload, sleep and fatigue, and efficiency demands, which should be investigated further. Research should also strive to identify other extraneous variables that influence or moderate trust in autonomy.

The low variance and minimal association with trusting existing automation raise questions regarding the validity of the construct and instrument. In this case, it concerns whether the instrument measures trust in the safety of autonomous systems or whether one is actually measuring something else. Considering the novelty of autonomous ships, we are indeed merely speaking of a dispositional trust, and at best an "initial learned" trust (Hoff & Bashir, 2015), and not the dynamic learned trust through interaction. One possible explanation is that "autonomy" might to a larger degree represent a socioculturally rooted attitude towards vague artifact, rather than the attitude towards the particular systems themselves. If we bear in mind that there are indications that seafarers see autonomy as "something else" than traditional "seamanship," i.e., in contrast to the ideal of seafaring and the competent seafarer Aalberg et al., (2024), it makes sense that "autonomy" is judged negatively based on the perceived threat against tradition. Especially for captains, it is easy to imagine that this could include the worry of losing their perceptions of being in control (legal, moral, and situational awareness) and confounding liabilities in case of accidents. Autonomous vessels also lead to radical changes to maritime traffic, for example, situations where conventional and autonomous vessels interact, which could provoke sincere uncertainty and thus impact perceptions of future safety. Autonomy is also fronted by new types of organizations with less history in the maritime industry. This could provoke uncertainty about the benevolence and intentions of actors. Ultimately, in the absence of concrete examples and information, respondents' trust is likely to be heavily informed by gossip, reputations, and other vague pre-existing knowledge types (Hoff and Bashir 2015) and, therefore, also with large individual variations. Consequently, "autonomy" provokes a variety of connotations based on individuals' experiences.

Further research is required to clarify the antecedents of and the validity of measuring trust in autonomy, for example, by improving questionnaires by asking respondents about their knowledge of the systems and using qualitative or mixed-method approaches.

4.4 Limitations and strengths

This study had several limitations. First, the dependent variable consists of only two items and has not been validated previously. Second, the data were not weighed, and it is a limitation that the study did not possess adequate data on the population of bridge crews, pertaining to the generalizability of the findings. Third, dispositional factors such as personality or digital literacy, aspects of trustworthiness of the technology, and other sociodemographic data were not available in this dataset. These and others could be relevant constructs for developing a more theoretically sound model (see Sect. 4.3). In general, there are concerns about whether psychological constructs can be measured through quantitative questionnaires (Michell 1997), calling for an interpretive and contextualized analysis of results. In this regard, it is notable that this research does not provide solid answers to what factors related to trust contribute to the results and that seafarers might interpret autonomy in various ways based on the systems' vague nature.

The main strength of this study is that it is the first to show how professional commitment relates to trust in autonomy in the maritime industry. This is an interesting finding in an industry where professional commitment is strong and autonomous vessels are increasingly high on the research and development agenda. Moreover, the study included many maritime professionals, possibly the largest study on bridge crew personnel's safety and work environment to date.

4.5 Conclusion and practical implication

This study contributes to the lack of research on the human and organizational aspects of autonomy (Porathe 2022) and the cultural and identity-related aspects of trust (Hynnekleiv and Lützhöft 2021) by exploring the role of professional commitment to trust in autonomy. From a mixed-method perspective, it also empirically contributes to the research on trust in autonomy dominated by formal modeling or qualitative studies, using a relatively high number of respondents. This work shows that although more research is needed to discover the antecedents and correlates of seafarers' trust in the safety of autonomous vessels, strong professional commitment is an important factor that on average relates to distrusting the safety of increased automation and autonomy. Future research should seek to validate the findings by including a job insecurity measure.

In terms of the safety of increased autonomy, the results of this study may be concerning. If we assume that those who are strongly committed to the maritime profession are also the most knowledgeable, it could be alarming that these workers are distrustful of the safety level. This could pertain to the fact that the trustworthiness of the technology is inadequate and should be improved before further implementation. A relevant further research area is, therefore, also to assess passenger trust or perceived safety on board autonomous vessels.

The fact that highly committed bridge officers exhibit lower trust in autonomy raises the question of how to develop and implement increased autonomy in order to achieve adequate trust levels. One pertinent way might be for academics and organizations to explore context-specific professional commitment in their domain to understand the key aspects that increased autonomy might represent a challenge. Specifically, building on partial support for interactions, one could highlight the potential differences between younger and older seafarers. Aiming for technology as supporting the human rather than the opposite is tangent with the growing focus on Industry 5.0 (Xu et al. 2021). Therefore, the involvement of professionals both in the development and testing of concepts as early as possible (i.e., a user-centered approach; Abras et al. 2004) would be beneficial both to increase the trustworthiness of the technology and the adequate trust that professionals exhibit towards them.

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Data availability Anonymized data can be made available upon request to the data owner (Norwegian Maritime Authority).

Declarations

Ethics approval The research project's research ethics were notified and approved by the governing regulatory instance National Centre for Research Data AS, protocol number 948264, approval date 17.03.2022.

Consent to participate Informed consent was obtained from all subjects who participated in the survey.

Competing interests The author declares no competing interests.

Declaration of generative AI and AI-assisted technologies in the writing process During the preparation of this work, the author used Paperpal AI Grammar Checker in order to proofread the manuscript. After using this tool, the author reviewed and edited the content as needed and took full responsibility for the content of the publication.

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