Impact of automation technology on gender parity in maritime industry

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Abstract

Autonomous technological advancement is projected to be a major step change in the world of shipping, creating new opportunities and challenges for maritime authorities and all stakeholders in the maritime sector. In this paper, we aim to explore the influence of automation technology implementation on employment opportunities for women seafarers/operators in the merchant shipping industry. A group of subject matter experts, which composed of shipowners, maritime education and training providers, and shipboard officers, were invited to elaborate on the perceived barriers and the prospects of female employment in the era of autonomous shipping, through a qualitative exploration. The collected data was analysed using thematic analysis to identify the potential challenges, barriers and opportunities for women employment in the maritime industry. The findings from this study reveal measures to improve gender parity in the maritime industry and help address the strategic directions of the International Maritime Organization (IMO) on women empowerment and the Sustainable Development Goal 5 (SDG 5) of the United Nations.

Keywords: Gender Parity, Empowerment, Autonomous Shipping, MASS, Thematic analysis

1. Introduction

The domain of remote-controlled and autonomous ship technology has been developing rapidly, driven by the demands of the industry and the recent advancement in sensor technology, connectivity at sea and decision support systems. The application of automation technologies is projected to induce a paradigm shift in maritime transport, having the potential to contribute towards a range of benefits to the industry. Such benefits could not only lower the frequency of human errors on board - as a consequence of fatigue and excessive workloads, but also enable a more efficient use of space in ship design, bringing fuel efficiency and a potential reduction in operating expenses. However, notwithstanding technological hurdles, remotely controlled and autonomous ship technology presents a myriad of challenges that are yet to be resolved,

including issues such as safety (Wróbel, Montewka, & Kujala, 2017), reliability, protection from cyber attacks, commercial incentives for shipowners and operators to invest in autonomous ships. Furthermore, how the novel technology and new operational concepts can be effectively incorporated into regulations also presents a significant challenge for regulators (Carey, 2017), since the instruments governing the safety of commercial shipping are designed on the assumption that ships are controlled and operated by seafarers on board.

The adoption of remotely controlled and autonomous ship technology is also projected to have a significant impact on human element involved – those at sea, onshore and the ship-shore interface. The introduction of automation systems implies that the manning levels on board will be further reduced. A "seafarer" may not ever actually go to sea, but rather work within Remote Control Centers (RCC) for navigation or at ports and dry-docks for maintenance. These new work scenarios will require different competencies than today, requiring the shipping industry as a whole to adapt (WMU & ITF, 2019).

A survey study carried out by Nautilus Federation with 1,000 maritime professionals across more than 20 seafaring unions has concluded that approximately 84% of maritime professionals consider that automation will be a threat to seafaring jobs, and 85% of them consider that autonomous ships will also have a negative impact on safety at sea (Nautilus Federation, 2018). The absence of human operators onboard exacerbates safety concerns as no skilled person is capable of responding locally in case of abnormal events, and the remote 'seafarers' may not develop the same level of situational awareness compared with those at the frontline (Kari, Gaspar, Gausdal, & Morshedi, 2018). Navigation-related risks, such as collision and stranding, may decrease with the adoption of a higher level of automation. However, non-navigation risks, such as fire, explosion and flooding, are still potential challenges on unmanned ships (Wróbel et al., 2017). Another major challenge will be to identify sufficient control measures that mitigate or reduce the potential risks associated with cyber-attacks as well as piracy threats.

The increased use of automation and digitalization in the maritime industry has already gradually changed the operational environment of ships and the knowledge required for seafarers (e.g., use of ECDIS). It has introduced a gradual reduction in manning and drive concerns on the decline in the demand of seafarers and related jobs. Future technological advancement of remotely controlled and autonomous ship technology may further gradually replace the manning needs, as the autonomous system is perceived to be capable of performing equally or outperforming the crew in terms of reliability and consistency - in some part of the operations. It has also been anticipated that autonomous ships may enhance the welfare and quality of seafarers' life by removing the hazardous working condition and physical distance to shore (Kari et al., 2018). Furthermore, operators capable of manoeuvring the ship from shore with qualification standards and relevant certification (when developed) will be in high demand. Investigation regarding the qualification for future seafarers and remote operators for safe operation has already being included in the interim guidelines for the test of Maritime Autonomous Surface Ship (MASS) (IMO, 2019). The new working condition under autonomous ships with shore-based bridge or control station may help appeal the attractiveness of working as a "seafarer" for the public. Particularly it poses a question that whether such changes with regards to autonomy implementation will have an influence on employment opportunities for women seafarers/operators in the merchant shipping industry.

Although governments and international regulatory bodies have prohibited gender discrimination in employment and have made considerable progress to minimize the gender inequality, the labour market in the merchant shipping industry remains overwhelmingly represented by male gender (Belcher et al., 2003; Kitada, 2010). In this paper, we are particularly interested *to explore if the working conditions under autonomous ships will help appeal the attractiveness of working as a seafarer to females*. By taking this as a research question, we looked into immediate impact of autonomous ships on gender parity, and aim to

identify potential challenges, barriers and opportunities for female employment in the maritime community. The findings shed light on the means by which to achieve gender parity in the maritime industry and help address the strategic direction of the International Maritime Organization (IMO) on women empowerment and the Sustainable Development Goal 5 (SDG 5) of the United Nations.

2. Women at sea

Seafaring has long been considered as a male-dominated occupation, the female gender in this industry has been historically underrepresented (Belcher et al., 2003; Kitada, 2010). Despite the improved operational conditions onboard merchant ships as well as the strategic promotion of women involvement by the industry stakeholders over the years, the female gender is still estimated to be only 1–2 percent among the 1.25 million seafarers in the world (Belcher et al., 2003). In recent years, female participation rate in shore positions has increased and an increasing number of women are enrolling in maritime studies (UNCTAD, 2018). However, the increased number of women seafarers on the merchant ships is also a reflection of broader trend of more women entering male-dominated profession, which cannot be solely attributed to the effort of the industry. In comparison to percentage of growth rate of female participation in aviation careers (e.g., 7% for US FAA pilot certificates, 4.3% for UK (Federal Aviation Administration, 2018)), the maritime industry is obviously not having the same pace. The majority of women seafarers are employed on cruise and passenger ships, especially for the hotel or other non-technical departments. Only one to two percent of female seafarers are employed onboard merchant ships (Guo & Liang, 2012). This seems not as a result solely from intentional discrimination, but is also related to several other factors that have prohibited active female participations in the merchant shipping industry. Previous research has identified several factors – e.g., gender-related stereotypes, maternity and health issues, harassment and bullying, lack of positive career options/discrimination, difficulties in exercising leadership – as the

potential barriers for female participation (Magramo & Eler, 2012).

Various research findings have indicated that the importance of gender diversity in the workplace and highlighted the benefits for women inclusions in teams and workplaces (Dwyer, Richard, & Chadwick, 2003; Julizaerma & Sori, 2012). Encouragement of female workforce in the maritime industry has been promoted for several reasons. Firstly, it is a desire to achieve gender parity in shipping – one of the important components of world economy. Secondly, it is due to market forces and shortage of seafaring labour, particularly officers (Magramo & Eler, 2012). The Baltic and International Maritime Council (BIMCO) and the International Shipping Federation (ISF) reported in 2005 that the global shipping industry would face a serious shortage of labour. For instance, by 2015, a 5.9% shortfall was estimated, which corresponds to 27,000 officers (Kitada, 2010). Thirdly, entry to maritime academies and universities has become more open to women than ever before (Belcher et al., 2003). To increase the public awareness that the industry is open to all members of the society, international organizations (e.g., International Maritime Organization, International Labour Organization, International Transport Workers' Federation) have taken a number of initiatives to promote the gender diversity in the maritime industry. However, barriers for female participation still persist. Investment in women seafarers has also been considered by the shipping companies as a short-term option due to maternity issues.

Academic exploration into women seafaring has been sparsely covered in literature, which in itself indicates the need for further exploration. To recognize the issues and barriers for women´s participation in maritime careers, and to identify measures to effectively address them so that the female workforce in the maritime labour market can be efficiently utilized is a persistent challenge of the industry and the regulatory bodies. By promoting the employment of women, the industry may benefit significantly from the more diverse perspectives and leadership styles in the knowledge economy that females represent, overcoming the shortages

in labour supply, and contributing to Sustainable Development Goals 5 for achieving gender parity (UNCTAD, 2018). On these premises, a preliminary exploration is conducted in this study to look into whether the adoption of automation technology will have an impact on the barriers of employment opportunities for women seafarers/operators in the shipping industry.

3. Degrees of ship automation

For identifying the unique challenges and opportunities autonomy presents in maritime domain, it is first essential to consider the degrees of autonomy, as different control and operation scenarios established for each degree of autonomy would determine the way the ship can be effectively managed, as well as the responsibilities and roles of operators onboard. The definition of autonomy is currently under debate, with various organizations (e.g., Lloyd's Register, Norwegian Forum for Autonomous Ships, Rolls-Royce) proposing different definitions. In this paper, we consider four levels of autonomy, as illustrated in Figure 1, according to the latest report on the Maritime Autonomous Surface Ships (MASS) in 100th session of IMO Maritime Safety Committee (IMO, 2018).

	Level of autonomy	*Human presence*	*Operational control*	*Human role*
Degree 1	Ship with automated processes and decision support	Yes	Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control	Supervision and operation
Degree 2	Remotely-controlled with seafarers on board	Yes	The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions	Backup to manoeuvre, supervise the systems
Degree 3	Remotely-controlled without seafarers on board	No	The ship is controlled and operated from another location. There are no seafarers on board	Monitoring and remote control
Degree 4	Fully autonomous	No	The operating system of the ship is able to make decisions and determines actions by itself	Monitoring and emergency management

Figure 1. Degrees of autonomy as described by IMO

The 1st degree of ship autonomy involves seafarers onboard to operate and control the systems and functions. Some operations can be automated, seafarers remain onboard ready to take control of the shipboard systems and functions. Under the autonomous ship scenario in degree 2, the ship is remotely controlled from another location but have very few crew members onboard to be able to intervene and take charge of ship when complex situation arises. In degree 3, the ship is unmanned and remotely controlled. For maritime accidents under the scenarios of degree 1 and 2, not only ship safety but also seafarer safety onboard is threatened. Only in degree 3 and 4, ship safety and seafarer safety are separated.

The adoption of autonomous ships in degree 2 and 3 will involve the establishment of RCC, as presented in Figure 2, in order to monitor, supervise and remotely control the ships for both normal and abnormal operations. The RCC does not necessarily has to be situated on shore, it could be for instance on a regular manned ship leading a convoy of unmanned/partially manned ships across the ocean (Rødseth & Nordahl, 2018).

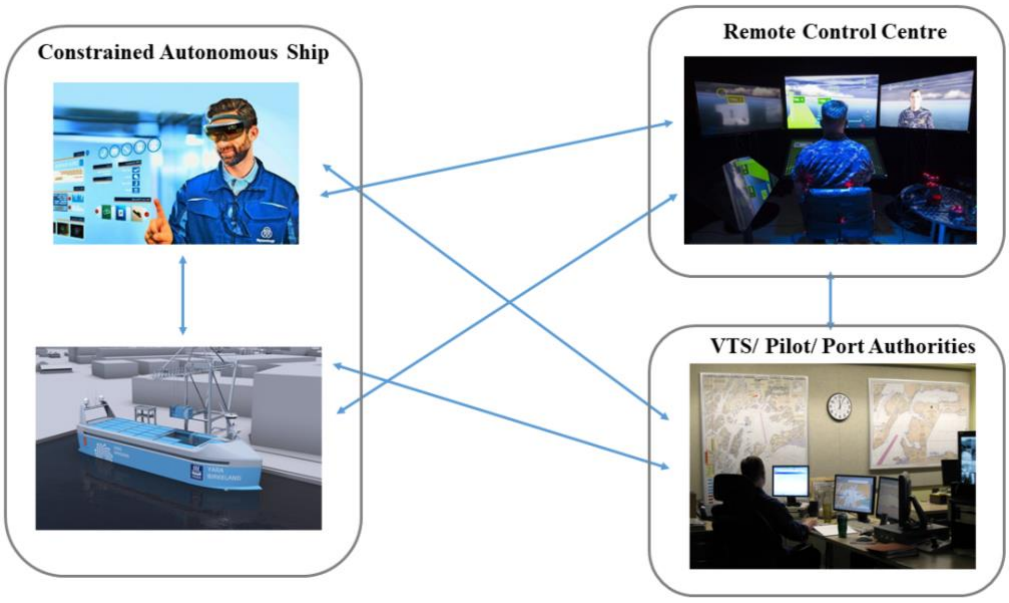

Figure 2. The future of autonomous ship operations; complex interactions between various functional centers. Image credits – Microsoft, Rødseth, Colclough, and Hatmaker (2019)

As of today, contemporary ships and many systems are already highly automated. In the continuum of autonomy as illustrated in Figure 1, autonomous ships with degree 2 and 3 are

projected to be the next natural progression in the industry. The increased bandwidth and reliability of internet will ensure enhanced control and monitoring of large aspects of ship operations from the shore. However, fully autonomous shipping, in this regard, is not foreseen to be reality in the near future, as it will have almost no control from ship owners and further introduce complex interaction scenarios between complete and partial autonomous ships. This also raises the issue of liability, as the ship will no longer have equivalence of master or other officers on-board or ship operators from RCCs (Carey, 2017). In this paper, the focus is on the supervised level of autonomous shipping i.e. degree 2 and 3.

If autonomous shipping continues to develop and proliferate, the seafaring profession as we know today, could be radically changed in the future (WMU & ITF, 2019). The hypothetical scenario of future maritime operations has shed light on the fact that the critical operations will be carried out by (relatively) small teams consisting of highly specialized members operating in a distributed setting and jointly managing/operating/supervising ships. Such scenarios call for differential training, optimum human-technology teaming and design support, and for research to explore the barriers and opportunities to fully capitalize on the benefits autonomous shipping offers. In particular, this research explores if the working conditions under autonomous ships will help appeal the attractiveness of working as a seafarer to females.

4. Method

Ensuring the credibility of qualitative studies depends on the quality of the data entry and how it has been condensed and interpreted (Graneheim & Lundman, 2004). This study was compiled with a sequence of procedures in order to draw valid inferences and explanations from the responses provided by the informants. The overall process and the involved questions are illustrated in Figure 3.

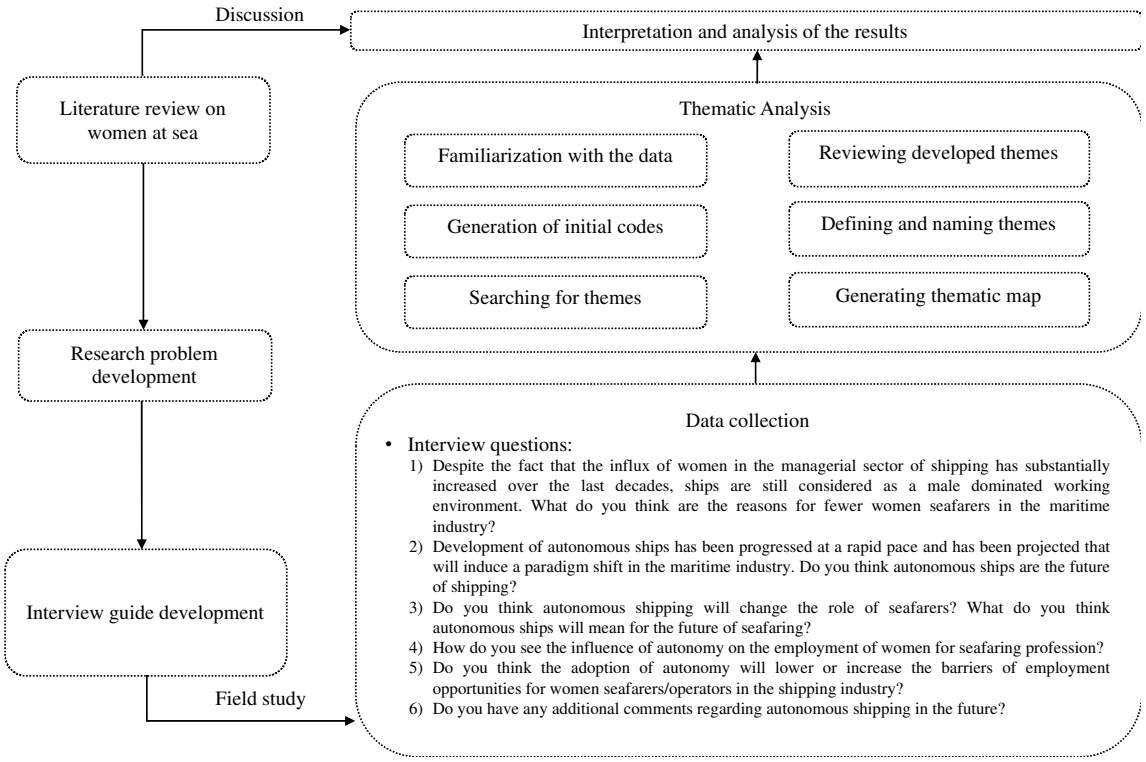

Figure 3. Overall research process

A qualitative exploration is performed with six core open-ended questions to elicit the opinions from the informants on contemporary development of autonomous maritime operations and perceived barriers and opportunities related to employment of women in the shipping industry. The literature review regarding women employment in shipping and the contemporary developments in the autonomous maritime operations were used as the basis for formulation of the questions. Recruitment of informants was performed with the contacts of authors through purposive sampling. Since the authors are situated in Norway, many of the contacts are working in this national context. By developing autonomous ship technology and leading the relevant research in this field, Norway is currently at the forefront in maritime autonomy. The participation in the study was anonymous and voluntary. A total of n = 21 informants answered all of the open-ended interview questions during the Spring of 2019. The informants consisted of varying level of job experience and profile. The demographic characteristics of the informants are summarized in Table 1.

Table 1. Demographic characteristics of informants

Characteristics	*Range*	*Frequency*	*Percent (%)*
Year of experience in the industry	Less than 5	14	67%
	6-10	4	18%
	11-15	1	5%
	More than 15	2	10%
Education	Graduate degree (Master, PhD)	11	52%
	Bachelor's degree	8	38%
	Some college (no degree)	1	5%
	High school or equivalent	1	5%
Workplace in the industry	At sea	6	29%
	On-shore	12	57%
	Shore-ship interface	3	14%
Industrial field	Shipping company	3	14%
	Ship management company	1	5%
	Maritime training institute/provider	3	14%
	Other maritime sectors	14	67%
Gender	Female	7	33%
	Male	14	67%

The informants comprised of various sectors in the maritime industry including shipowners, maritime education and training providers, and shipboard officers. Females represented approximately one-third of the sample size. Data was collected with informed consent and assurance of remaining responses and personal information made confidential and anonymized.

Thematic analysis procedures (Braun & Clarke, 2006) – as illustrated in Figure 3 – were used as analytic method to guide the authors in describing the patterns across the collected data. In contrast to other qualitative analysis methods such as discourse analysis or content analysis, thematic analysis does not need to be connected to any pre-existing theoretical framework (Braun & Clarke, 2006), which provides a greater degree of flexibility to generate new themes. Two researchers engaged in the process of searching emerging patterns and building arguments through analysing and interpreting the textual data. The results were reflected and discussed in the light of prior research.

5. Results

The thematic analysis of the qualitative data has yielded identification of several themes related to each of the interview questions.

Barriers to gender parity in maritime careers

The research commences with exploring the barriers for women participation in maritime careers and the collected data has revealed a variety of factors that negatively influence active female participation in the maritime industry. Barriers for women participation in maritime careers exist at both side of the dyads (i.e., employees and employers), and can be further broadly grouped into several categories i.e., physical, psychological and social barriers. A thematic map of the barriers to women employment in maritime careers is developed by the authors and illustrated in Figure 4.

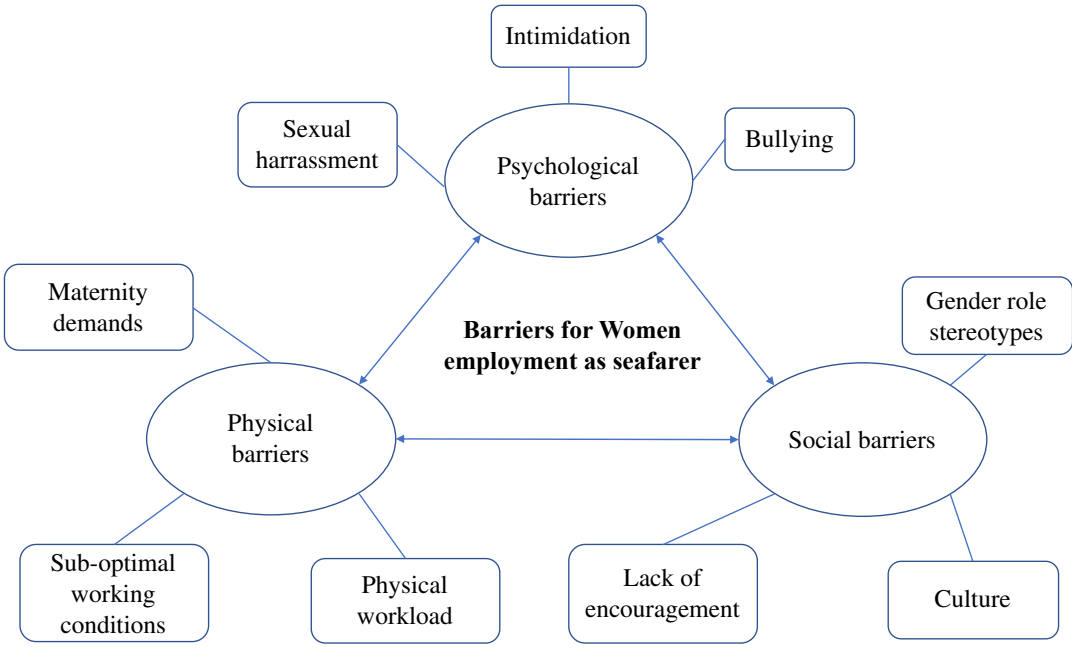

Figure 4. Thematic map of the barriers to women employment in maritime careers

Firstly, seafaring has been historically considered as a male-dominated profession due to the hostile working environment, the need for physical strength in normal and abnormal situations at sea. The design of the ship, job descriptions and arrangements are generally modelled on

male characteristics and physique, which conforms the patterns of male life. Female needs and life pattern have not been taken into serious consideration in design and operation of the ship.

These physical barriers influence career entry for women in this sector, and the unbalanced gender ratio also influenced the construction of the female identity. One informant stated that:

> "Seafaring is not an attractive type of job for women culturally and physically. It has been a very historically masculine culture on-board ship, and it still is. Those women I have met as seafarers has either been more masculine or at least more comfortable with a masculine culture than average."

Furthermore, psychological barriers such as self-efficacy, motivation and work interest are also identified as influencing factors. Sexual harassment and abuse onboard ships are still key issues facing female seafarers, as mentioned by the informants. The hostile working condition and the culture onboard does not stimulate work interest and passion for many women in considering maritime careers, and it also influences their occupational self-efficacy, the level of confidence towards their capabilities to work onboards ship.

Although the modern ships with adoption of technologies have replaced the role of seafarers from manual operation to a more supervisory and monitoring position with less physical demands, many women still find it challenging to work as a seafarer in merchant ships due to several social barriers. The ship is self-contained, isolated, hierarchically controlled and embedded with masculine values, which offers limited flexibility and opportunities for frequent interactions with friends and families to fulfil the social expectations towards women. It is also incompatible with the women who have caring responsibilities. With lack of women representation in merchant ships, the environment prohibits the women seafarers to have active and desired social life compared to those in shore-based occupations. As informants explained,

> "It is hard to breach status quo; women will not seek work where there are relatively few women".

In addition, the study also revealed that work interests and perception regarding their self-efficacy to work at sea presents a barrier to pursue maritime careers. As seafaring has long been considered as a male occupation, the gender role biases remain persistent which lead to potential intentional discrimination for employment. The employment standards and expectations are often based on the assumptions that certain traits, qualities and skillsets are desired or mandatory for optimal performance of the job. Those required traits (e.g., assertiveness, detachment and physical strength) are often predominantly associated with male characteristics. The duties that demands physical strength (e.g., lifting heavy machines, cargo clearing, pulling mooring ropes) are perceived to be more suited to men. Negative stereotypes were behind the reluctance supporting women candidates for same position. The assumptions lead to difficulties for women to get access to the job opportunities and career advancement in this field. These obstacles are also the major reasons for relatively short periods of time onboard vessels in their career path. Many women seafarers back out and look for shore-based jobs for better lifestyle and career prospects. The findings also show that traditional expectations towards work roles concerning women's efficacy for maritime careers still persist. In general, barriers exist in every aspect of work in their career practice for women onboard the merchant ships.

Impact of autonomy on women´s participation in shipping

As noted by most of the informants, the seafaring profession as we know today could be radically different in the future with the development and adoption of autonomous shipping technologies. A seafarer may not ever actually to go to sea, but rather work within shore control centres for monitoring and controlling of ships. These new job demands will likely create new roles and career opportunities in this industry. Several barriers as described above can be predicted to be removed with implementation of autonomy technology, which leads to the assumptions by several informants that the changes with regards to autonomy will lower the barriers of employment opportunities for women seafarers in the merchant shipping industry.

The reasons for this assumption can be summarized into several points: 1) autonomous shipping will create new functions that don't carry with them a history of male occupation; 2) implementation of automation technology will potentially remove the physical barriers and male-oriented working culture and condition. Explained by several informants:

> "These types of workplaces (with seafarers on shore) might suit women "in general" more than seafaring today, which is physically challenging, long commute time from home and the established masculine dominated social culture."

The analogy of working in an RCC being equivalent to a regular office job, thus removing the "special" nature of seafaring was presented by the informants. Due to several perceived undesirable characteristics related to onboard job removed, the informants thought that the domain could appeal equally to females. However, the gradual progression towards degree 2 and 3 autonomous operations could take unspecified transition time. Due to the relative uncertainty regarding the automation technology and its impact on seafarers, there were some respondents calling for cautious optimism:

> "It is too early to tell now. Adapting autonomy could more likely lower the barriers for women to join the shipping industry. However, it depends upon what type of jobs are created in an autonomous shipping industry and how these jobs are promoted among women".

Although the majority of the informants perceive that the adoption of autonomy will lower the barriers of employment opportunities for women seafarers, some informants also argue that autonomy will not have any influence, or potentially could increase the barriers. An informant explained that:

> "Future seafarers will need more of a monitoring role than today – monitoring autonomous systems on board. We can't run any computer or

> mobile phone without getting software faults. Personnel with IT competence might be more normal to be on-board of semi-autonomous ships in the future. However, the IT sector is also dominated by males. But in contrast to the seafarer profession, I believe that the explanation is more of a cultural aspect for IT".

Due to the existing gender skew favouring the males in the IT sector, the informants felt that more jobs or roles created requiring specific IT skills will mean mere extension of the status quo in the maritime industry with male gender continuing to be appearing overly represented in these new profiles.

In summary, the respondents concluded that, the adoption of autonomy will improve the quality of seafaring jobs and aiding elimination of several key barriers for women participation in the maritime industry, which likely increase the possibilities for work-family integration, improve the working environment and flexibility, and reduce the level of physical demanding jobs and risk exposure. However, as observed from the data, adoption of automation technology could also mean that the maritime sector evolves to an information technology dependent and highly technical domain, which may still favour the male gender due to the existing unbalance in the skilled worker talent pool.

6. Discussion

Despite the fact that influx of women in the managerial sector of the maritime domain has substantially increased over the last decades (UNCTAD, 2018), ships are still considered as a male dominated working environment. Extended on previous studies, which have mainly emphasized on two contributing factors to low female participation – working conditions (including the timing and place of work), and gender stereotyping (Turnbull, 2013), our qualitative findings revealed additional psychological, social and physical barriers for women

in pursuing careers in the maritime industry. The findings also shed light on how implementation of automation will have an influence on these barriers.

The introduction of autonomy in ship operations has the potential to restructure majority of the work processes. Research studies have examined the impact of autonomy on general workplaces and highlighted a positive effect of automation on wellbeing, life and job satisfactions (Kaye & Sutton, 1985). The present study echoes the opinion of this line of studies and argues that the increased autonomy will improve the quality of work and wellbeing of seafarers. Better working conditions and commute opportunities will certainly offer considerable social and economic benefits for both employees and employers. With the new work processes and requirements for remote maritime operations, diversity in teams could prove to be beneficial in decision making. With these arguments, the inclusion of female gender could mean not only more balanced gender ratio for the sake of representation, but due to actual benefits offered by such team composition.

The barriers that will be potentially eliminated with adoption of automation will be related to the social environment and physical working conditions. The future of seafaring work and the creation of more shore-based positions in the maritime industry will certainly remove several physical barriers and risk exposure, improve the social infrastructures of traditional seafaring jobs, and open up possibilities for females to pursue both their material wellbeing and to reconcile work and family life.

However, psychological barriers such as work interest and self-efficacy in this highly technical career may still remain unchanged. In the case of increased demand for technological competencies and IT skills, the industry will favour the existing status quo as male gender is overly represented in the associated job markets. Thus, the expected paradigm shift in the nature of maritime operations may not particularly improve women participation in this industry. This point partly aligns with the International Monetary Fund (IMF) analysis regarding how

technological advancement would affect gender differences across occupations, which has concluded that automation will not particular improve gender representation (Brussevich et al., 2018). Instead, a larger proportion of the female workforce will be at high risk for displacement, as women conduct more routine and automatable tasks compare to men across all sectors and occupations. To counteract or avoid this barrier, active promotion and support of females with emerging competencies will be required for operating the ships as a consequence of fundamental changes in some key ship operations. In any case, the introduction of automation merely reshapes the dependencies on human operator in the system and the emphasis might shift from operators to the designers and supervisors of the system (Leveson, 2011). The flexibility and creativity of the human element will still constitute the obvious strengths in autonomous operations (Ahvenjärvi, 2016).

Based on the identified barriers that women face when entering the maritime careers, two implications can be generated. The correction of under-representation of female in shipping will require structural changes from a systemic perspective, to ensure that the system, from design to operations, could conform female characteristics and life patterns. Secondly, in addition to implement measures to mitigate physical and social barriers, initiatives should be taken to proactively address gender role biases and create work environments that can build self-efficacy.

Based on the result and discussions presented above, several recommendations can be generated as below for the industry and the regulatory bodies:

[1] To attract more women for maritime careers requires the maritime industry and the regulatory bodies to holistically and proactively address the gender bias issues and construct physical working conditions and structures suitable for both genders;

[2] Create a level playing field for both genders for the newly emerged professions in the era of autonomous shipping;

[3] Facilitate research on the benefit of gender diversity on group decision making and problem solving;

[4] Stimulate the self-efficacy and work interest of women in pursuing their careers in the maritime domain through promoting the public awareness of re-defined gender-neutral seafaring professions;

[5] Improve structural mechanisms that would be beneficial to circumvent the negative impact of stereotypical attitudes towards women in shipping;

[6] Endow women with necessary digital skills and future competence of seafaring through training and education to raise the quality and quantity of human capital to effectively adapt to new technologies.

As gender parity and empowering women were included as an important target (SDG 5) under 2030 Agenda for sustainable development, with several indicators to reflect the level of achievement by 2030. The recommendation generated in this study may have particular implication for the maritime industry and regulators to generate direction to address two indicators under SDG 5. Specifically, SDG indicator 5.1 which emphasizes on ending all forms of discrimination against all women and girls everywhere, as well as indicator 5.5 to ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.

Several limitations need to be mentioned. The findings need to be followed up and further studies are needed using different methodologies to minimize the subjectivity of qualitative research (Dixon-Woods, Shaw, Agarwal, & Smith, 2004). The number of informants is limited, and the sample is dominated by people with relatively short experience from the industry, higher education qualification and mostly shore-based occupations. Majority of the data are collected in a Norwegian context. This national context represents, however, also one of the highest levels of education and gender parity worldwide. This study should therefore be

followed up with a broader sample of informants. It would also be interesting to perform case studies on shipping companies that follow some of the recommendations generated in this study. Furthermore, the qualification requirements for those working on autonomous ships and in maritime RCCs, and the legal implications of autonomous ships are worth of further exploration. Future research should also be directed towards exploration of whether autonomous shipping would help women breach the glass ceiling effect, that is overcoming the restrictions of women reaching top positions.

7. Conclusion

The present study conducted a qualitative exploration to develop new theoretical and practical insights through the process of exploring the rich data. The new theoretical insights include several psychological, social and physical barriers for women in pursuing careers in the field of maritime industry. Several of these barriers will be potentially removed with implementation of automation technology, which leads to the assumption that the changes with regards to autonomy will lower the barriers of employment opportunities for women seafarers in merchant shipping. However, the future shipping industry – which will be evolved to a highly complex technical domain – still remain as a male dominated area, and women in general may still remain un-inspired to pursue their career within this field.

Given the need for a highly technically skilled workforce, to attract more women for maritime careers requires the industry and the regulatory bodies to holistically and proactively address the gender role bias issues and construct physical working conditions suitable for both genders, empowering women with future competencies, and stimulating the self-efficacy and work interest of women in pursuing their careers in the maritime domain.

8. Reference

Federal Aviation Administration, F. A. (2018). CAPA - Centre for Aviation. Retrieved from https://centreforaviation.com/analysis/reports/women-airline-pilots-a-tiny-percentage-and-only-growing-slowly-432247

Belcher, P., Belcher, P., Sampson, H., Thomas, M., Zhao, M., & Veiga, J. (2003). *Women seafarers: Global employment policies and practices*: International Labour Organization.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Brussevich, M., Dabla-Norris, E., Kamunge, C., Karnane, P., Khalid, S., & Kochhar, K. (2018). *Gender, Technology, and the Future of Work* (I. M. FUND Ed.): International Monetary Fund.

Carey, L. (2017). All hands off deck? the legal barriers to autonomous ships. *NUS Law Working Paper No. 2017/011. Available at SSRN: https://ssrn.com/abstract=3025882 or http://dx.doi.org/10.2139/ssrn.3025882*.

Dixon-Woods, M., Shaw, R. L., Agarwal, S., & Smith, J. A. (2004). The problem of appraising qualitative research. *BMJ Quality & Safety, 13*(3), 223-225.

Dwyer, S., Richard, O. C., & Chadwick, K. (2003). Gender diversity in management and firm performance: The influence of growth orientation and organizational culture. *Journal of Business Research, 56*(12), 1009-1019.

Nautilus Federation. (2018). *Future proofed? What maritime professionals think about autonomous shipping*. Retrieved from London: https://nautilusfederation.org/wp-content/uploads/2018/02/report_auto_8.2.18.compressed.pdf

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse education today, 24*(2), 105-112.

Guo, J.-L., & Liang, G.-S. (2012). *Sailing into rough seas: Taiwan's women seafarers' career development struggle*. Paper presented at the Women's Studies International Forum.

IMO. (2018). Working group report in 100th session of IMO Maritime Safety Committee for the regulatory scoping exercise for the use of maritime autonomous surface ships (MASS). . *MARITIME SAFETY COMMITTEE 100th session*.

IMO. (2019). *Regulatory Scoping Exercise For The Use Of Maritime Autonomous Surface Ships (MASS)*. International Maritime Organization.

Julizaerma, M. K., & Sori, Z. M. (2012). Gender diversity in the boardroom and firm performance of Malaysian public listed companies. *Procedia-Social and Behavioral Sciences, 65*, 1077-1085.

Kari, R., Gaspar, H. M., Gausdal, A. H., & Morshedi, M. (2018, 2018). *Human Interactions Framework for Remote Ship Operations*.

Kaye, A. R., & Sutton, M. J. D. (1985). Productivity and quality of working life for office principals and the implications for office automation. *Office Technology and People, 2*(4), 267-286. Retrieved from https://doi.org/10.1108/eb022637. doi:10.1108/eb022637

Kitada, M. (2010). *Women seafarers and their identities*: Cardiff University.

Magramo, M., & Eler, G. (2012). Women seafarers: Solution to shortage of competent officers?

Microsoft, Rødseth, Ø. J., Colclough, B., & Hatmaker, T. (2019). In *1st: https://news.microsoft.com/europe/2017/04/24/thyssenkrupp-uses-hololens-magic-bring-custom-stair-lift-solutions-directly-home/ 2nd: https://blogg.sintef.no/sintefocean-nb/autonome-skip-fjerner-40-000-lastebiler-fra-veien/ 3rd: https://alaska.coastguard.dodlive.mil/2018/05/unit-spotlight-marine-safety-*

unit-valdez/ 4th: https://techcrunch.com/2017/10/19/anduril-trae-stephens-battlefield-vr-ar/?guccounter=1&guce_referrer_us=aHR0cHM6Ly93d3cuZ29vZ2xlLm5vLw&guce_referrer_cs=ebNs9WI7cCsFhPAtyA0l9w.Date accessed: 15 June 2019

Rødseth, & Nordahl. (2018). Definition of autonomy levels for merchant ships, Report from NFAS, Norwegian Forum for Autonomous Ships. doi:doi:10.13140/RG.2.2.21069.08163

Turnbull, P. (2013). *Promoting the employment women in the transport sector – obstacles and policy options* (Vol. Working Paper No. 298). Geneva: Sectoral Activities Department.

UNCTAD. (2018). *Review of Maritime Transport 2018*. Retrieved from https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf

WMU, & ITF. (2019). *Transport 2040: Automation, Technology, Employment - The Future of Work* (Vol. (Online) 978-91-984865-2-0). World Maritime University.

Wróbel, K., Montewka, J., & Kujala, P. (2017). Towards the assessment of potential impact of unmanned vessels on maritime transportation safety. *Reliability Engineering & System Safety, 165*, 155-169. Retrieved from http://www.sciencedirect.com/science/article/pii/S0951832016303337. doi:https://doi.org/10.1016/j.ress.2017.03.029