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Research Article

Impact analysis of innovation and gendered constraints in the fisheries sector of southern Ghana

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This paper adopts the multinomial endogenous treatment effect approach to analyze the impact of innovation choices on the income of 230 fish workers in the Greater Accra and Central regions of Ghana, while the Kendall's ranking technique is applied to analyze the constraints to innovation. Findings show that technological and non-technological innovations available to fish workers have positive impacts on their income. Specifically, savings, credit access, and support service are identified to have positive impacts on income while gender and membership of a fish workers' association have negative impacts on income. The most pressing constraints to innovation faced by female fish workers are cultural/ethnic restrictions, social exclusion, and time constraints. On the other hand, a high dependency ratio and discrimination in access to resources are the most pressing constraints faced by male fish workers. The paper recommends that stakeholders should continue to offer support services to fish workers. In addition, lending institutions should make credit accessible at lower interest rates. Interventions by the Ministry of Fisheries and Aquaculture Development and development agencies that aim to solve constraints of fish workers should be approached from a gender dimension.

Keywords: innovation, gender, income, fish workers, southern Ghana

Introduction

Fish is a highly affordable and accessible animal protein source for households in urban and peri-urban areas of Ghana (Béné et al. 2016; Onumah et al. 2020). The fishery sector generates a lot of revenue for millions of low-income families (both men and women) thereby making contribution to their food security needs, either directly or indirectly (Béné et al. 2015; World Bank 2012; Perry and Sumaila 2007). According to Belhabib, Sumaila, and Pauly (2015), the fisheries sector is estimated to generate revenue of about US$341 million and contribute about 3% to Ghana's GDP yearly.

In Ghana, the marine fisheries is one of the major sources of livelihood for many coastal villages and their dependents (Nunoo et al. 2014). The small-scale sector in the marine fisheries plays a major role in fish production and engages about 80% of fishers in employment. The majority of Ghanaians in coastal communities depend highly on small-scale fishing for sustenance (Béné et al. 2016). Despite these benefits, Danquah et al. (2021) revealed a decline in fish landings among artisanal fisheries in the country which is likely to threaten fish food security. Onumah et al. (2023) also reported that fish production from captured fisheries has continually declined since the mid-1990s. Béné et al. (2016) noted that the situation may affect the wellbeing and income of fisheries dependent communities if not properly addressed. Locke et al. (2017) proposed adaptation and innovation as strategies for meeting the challenges in the fishing communities.

Innovations are mainly used to achieve a particular aim and improve on existing methods or techniques. Ragasa et al. (2014) defined innovation as practices or techniques, skills and know-how, tools or equipment, which are applied to increase productivity, reduce cost of production and processing, improve income, and make savings on scarce resources including labour. The concept of innovation is seen in the Ghanaian society as highly advanced inventions and mainly technological processes (Blake and Hanson 2005). However, some studies made efforts to distinguish between the concept of innovation and technology transfer. Technology transfer has been characterized as innovation adoption (Sazali and Raduan 2011), technology or knowledge application (Phillips 2002), developed by an external organization. Sazali and Raduan (2011) simply noted that technology transfer is the application of technology to new uses or application by a new user.

Blake and Hanson (2005) noted that innovations outside of sectors associated with technology, although recognized are not given the needed attention. Their study added that the economic activities that are largely associated with technology are activities that are mainly performed by men. Government and other development partners concerned with innovation-focused economic development also centre more on technological innovations than other forms of innovative activity in their efforts to increase local wealth. Findings by Kawarazuka and Prain (2019) indicated that women's innovation are on small scale and usually less technological. Akyempon et al. (2013) recorded that the marine sub-sector employs about 139,000 male fishers and about 1.9 million females in Ghana. These women play key roles in fish preservation, marketing, and processing.

King (2005) stated that the multifariousness contributed by gender-mix led to better functioning in innovation which has a positive effect on performance. As noted by the World Bank (2005), underrating gender inequalities may be consequential to the wellbeing of individuals and their ability to mitigate poverty. World Bank, FAO and IFAD (2009) also suggested that programmes targeted at increasing outputs and incomes can be made effective if

issues relating to gender are incorporated. Although the OECD/Eurostat (2018) defined innovation as an outcome and the activities by which innovation take place, Ragasa et al. (2014) noted that not all innovations are beneficial and responsive to the needs of their expected users. It therefore necessary to ascertain challenges faced by fish workers in employing innovation techniques and whether the innovations available to them are gender based and meeting their expected benefits of income generation.

This paper thus seeks to assess the impact of innovation on the income of fish workers using the multinomial endogenous treatment effect technique, whilst adopting the Kendall coefficient of concordance (KCC) to identify, and rank constraints to innovation from a gender dimension. Following the introduction, the paper outlines the theoretical concepts underpinning gender and innovation studies, overview of the study area, data description, conceptual framework and method of analysis. It highlights the results, discussions and concludes with recommendations for policy considerations.

Theoretical framework

Gender inclusivity in innovation

The need for a more holistic approach in addressing innovation have been stressed by policymakers (Alsos, Ljunggren, and Hytti 2013; Lindberg and Schiffbänker 2013). Drawing on their arguments, widening the understanding of innovation apart from technological innovation, whilst acknowledging innovative efforts by actors and fields that are being marginalized in policy and research could be very beneficial (Lindberg et al. 2012). Belghiti-Mahut, Lafont, and Yousfi (2016) emphasized the need to include marginalized concept (gender perspective) in innovation studies. The theory of 'Inclusive Innovation' is described as innovations which 'include' 'new' development with respective to a group of individuals or certain positions that are marginalized or disfavored in areas that are being projected for development through wide range of innovation types. The 'inclusive' makes reference to the societal opinions that allows for the marginalization. This perspective may include class, ethnicity, sexuality, gender, and age. 'Newness' under inclusive innovation can be described as involvement of formerly marginalized group of people and their positions in a a manner that is novel to the specific context or quite new to the world (Lindberg, Forsberg, and Karlberg 2015). Key among the studies undertaken on inclusive innovation is gendered innovation (Belghiti-Mahut, Lafont, and Yousfi 2016).

Gendered innovation

Drawing on the earlier submissions, a defined array of role players has given special recognition in research and policy on innovation, whilst proceeding on distinct gendered dimension of separatism and hierarchy where innovation by men is noted to be of higher value than that of women. Thus, innovations of women perspectives have been demoted (Blake and Hanson 2005; Pattersson and Lindberg 2013). Following these submissions, 'gendered innovation' is being modified and formulated in a way that challenges the usual gendered patterns in society (Lindberg, Forsberg, and Karlberg 2015). The 'gendered' aspect concerns the process of potentially undoing structures where the innovations related to men are assigned a greater value compared to the ones related to women. The 'newness' in innovation by gender dimension relates to the novelty of innovative shift of structures in society by gender perspectives. Some innovation choices identified in this paper are presented in Table 1, reflecting on technological innovations used by fish workers (e.g., GPS tracker, Echo sounder, 'Ahoto' Oven, and FTT – Thioarye Smoking Technology oven). These are normally developed and handed down by organizations to fisher folks to enhance their activities. Table 1 also consists of non-technological innovations developed, improvised, or modified by the fish workers to solve problems such as reducing fish spoilage and ensuring continuous supply (e.g., racks, cases, fishing in nearby seas, and buyer-seller arrangements or networks).

Conceptual framework

The conceptual framework revealed in Figure 1 demonstrates the impact of innovation decision by respondents. The results of innovation decisions by the respondents may reflect activities such as the ease with which operations are carried out, consumer attitudes towards fish products, and others which also affects the income derived from fish work. Innovations are mostly used to derive some benefits hence it is expected that respondents who make use of innovations are likely to have higher income benefits compared to non-innovators (Tambo and Wünscher 2016). In addition, socioeconomic factors such as gender, work-specific factors and institutional factors may define the nature of work which in turn may influence the innovation technique chosen by fish workers and the outcome of innovation choices. Also, fish workers may face some challenges such as resource constraints, time constraints and other factors which are likely to influence the choice of innovation to use. According to Tambo and Wünscher (2016), these decisions may have an impact on the outcome of fish workers especially in terms of income derived.

Materials and methods

Empirical models

Fish workers' choice of innovation is voluntary self-selection implying that the research is not set up as a controlled experiment where respondents can be sampled from treated and untreated group. Hence, fish workers' decisions regarding the choice of innovation is probably influenced by variables which cannot be observed or quantified (such as motivation and managerial skills) that may be expected to correlate with the outcome variable (income from fish work). This condition requires a selection correction estimation method such as the Multinomial Endogenous Treatment Effect *(METE)* technique noted by Deb and Trivedi (2006a, 2006b). This model accounts for unobserved and observed heterogeneous characteristics of the sampled respondents. The *METE* model comprises of two stages. In the first stage, the model specifies the adoption decision relating to

Table 1: Innovation categories of fish work.

Innovation category	Examples
Technological innovation	• GPS tracker • Echo sounder • 'Ahotor' Oven • FTT (FAO-Thioarye Smoking Technology) oven
Non-technological innovation	• Racks • Cases • Fishing in nearby seas • Buyer-seller arrangements or networks

***Source*:** Field survey (2020)

innovation techniques in a mixed multinomial logit selection technique. The technique then estimates the impact of each innovation technique on the outcome variable, whilst employing the ordinary least square *(OLS)* with selectivity rectification conditions in the second stage.

Following Deb and Trivedi (2006a, 2006b) and as specified in model (1), $V_{ik}^{*}$is used to represent the latent factor that captures the income of fish workers which is as a result of choosing innovation techniques *k (k = 0, 1 ... .k)* instead of choosing any other technique *j*.

$$V_{ik}^{*} = z_i^{'} \alpha_k + \sum_{j=1}^{K} \delta_{jj} l_{ij} + \eta_{ik} \quad (1)$$

The variable $z_i$denotes the vector of exogenous socioeconomic covariates which affects the choice of a particular innovation technique on the outcome; α_k = parameter vectors to be estimated; η_{ik} = identically and independently distributed errors; and q_{ij} = latent variable that integrates unobserved features mutual to the respondents' choice of innovation and the outcome factor (fish workers' income), such as the technical capacity of the fish worker in analyzing innovation techniques (Mutenje et al. 2016).

Following Deb and Trivedi (2006b), fish workers who did not choose any innovation technique is denoted by $k = 0$ and $V_{i0}^{*} = 0$. V_{ik}^{*} is not observed but one can detect the options of innovation techniques in a binary variable form identified by the vector$p_i = p_{i1}, p_{i2}, p_{i3} \ldots\ldots\ldots p_{ik}$. Similarly, $q_i = q_{i1}, q_{i2}, q_{i3} \ldots\ldots\ldots q_{ik}$.

The probability of treatment is specified as:

$$\Pr(p_i|z_i, q_i) = g\left(z_i^{'} \alpha_1 + \sum_{j=1}^{k} \delta_{1j} q_{ij} + z_i^{'} \alpha_2 + \sum_{j=1}^{k} \delta_{2j} q_{ij} + \ldots\ldots\ldots + z_i^{'} \alpha_J + \sum_{j=1}^{k} \delta_{kj} q_{ij}\right) \quad (2)$$

The function g is a fitting multinomial probability distribution that may have a mixed-multinomial-logit (MMNL) structure (Deb and Trivedi 2006b) specified as:

$$\Pr(p_i|z_i, q_i) = \frac{\exp(z_i^{'} \alpha_k + \delta_k q_{ik})}{1 + \sum_{j=1}^{k} \exp(z_i^{'} \alpha_j + \delta_j q_{ij})} \quad (3)$$

Subsequently, analysis of the impact of choosing an innovation technique on the outcome variable (natural log of income) from fish work is expressed as:

$$E(y_i|p_i, x_i, q_i) = x_i^{'} \beta + \sum_{k=1}^{K} \gamma_j p_{ij} + \sum_{k=1}^{K} \lambda_k q_{ik} \quad (4)$$

The variable y_i refers to the outcome of innovation technique considered which represent the income of the *ith* fish worker, x_i denotes exogenic randomly correlated variables with vector parameter, β. The coefficient, γ_j is an indication of the treatment outcomes in relation to fish workers who did not adopt an innovation (non-adopters); the parameter, γ_j reveal the effects of innovation adoption on fish workers' income. Taking into consideration that $E(y_i|p_i, x_i, q_i)$ is an expression of the latent variables (q_{ij}), the outcome factors are controlled by unobserved features which may also have repercussion on the selection into the treatments. When the variable loading estimates (λ_j), have either positive or negative directions, treatment and outcome may correlate positively or negatively via unperceivable attributes. That is, there could be a positive/negative selection, with γ and λ, the linked vector estimates (Manda et al. 2016). The analysis follows a normally distributed Gaussian function since the outcome variables are continuous and the outcome model is estimated by the Maximum Simulated Likelihood (MSL) method.

Parameters of the fitted model can be estimated even if the regressors in the treatment equations are similar to parameters in the outcome equation. However, Deb and Trivedi (2006a) recommended the use of at least one instrumental variable or exclusion restriction in the treatment equation for a more robust estimation. Manda et al. (2016) and Di Falco, Veronesi, and Yesuf (2011) indicated that finding a valid instrument is an empirical and theoretical challenge for researchers. Training received or information (Olawuyi and Mushunje 2020) on any of the innovation techniques was used as an instrumental variable. The instrumental variable is binary hence it is coded zero if no training or information was obtained and one if sampled respondents had previous training or information. Studies have indicated that training or information can serve as a valid instrumental variable as used also by Di Falco, Veronesi, and Yesuf (2011); and Manda et al. (2016). The empirical model adopted by this current

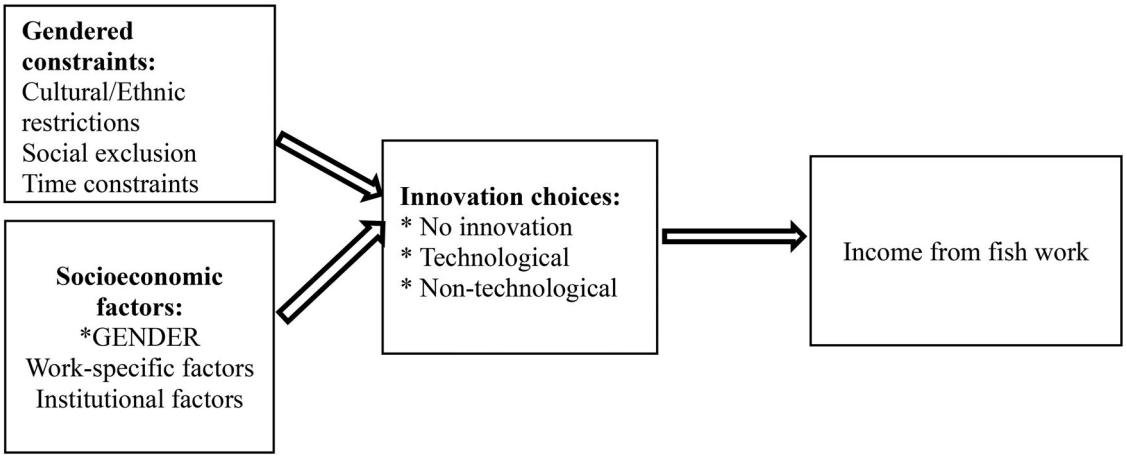

Figure 1: Conceptual framework (adapted from Muniru 2013).

paper was motivated by Di Falco, Veronesi, and Yesuf (2011); and Manda et al. (2016). Consistent with Gebremariam and Wünscher (2016), this study used the *METE* and suggest that variables which influence the choice of innovation is likely to translate into a positive outcome variable (Ogwuike, Arouna, and Ogwuike 2022).

Drawing on the work of Di Falco, Veronesi, and Yesuf (2011), the acceptability of the instrument was verified by undertaking a simple falsity test. Di Falco and Veronesi (2013) demonstrated that a factor is a legitimate instrumental variable if it influences the act of making a choice for an innovations but does not however affect the resultant variables among the respondents who did not adopt an innovation. The results from Table A1 in the Appendix show that information or previous training received on innovation techniques is significant statistically among some of the adoption models (technological innovation) but not significant in influencing the outcome variables (income from fish work). Thus, information received, or previous training acquired on innovation techniques is a valid instrumental variable. Training was largely carried out by extension personnel in the study area. Some fish workers also received information on the use of techniques from fellow colleagues.

Gendered constraints to innovation

Different studies have presented explanations on how gender affects the ability to innovate and make decisions around innovations. Nahlinder (2010) believed that the innovative abilities of women are hindered by low prioritization of work issues over family issues and lack of self-confidence. According to Farnworth (2009), women entrepreneurs identified their inability to achieve an appropriate work-family balance as their most pressing challenge. Credit bias represents another barrier to women carrying out innovative activities. Women generally have less access to collateral than men which makes it difficult for them to access land titles and other productive resources. Cultural factors such as seclusion of women and norms surrounding the role of women in society also hinder access to credit and other services and may cause women to refrain from applying for credit (FAO 2002). Other studies are of the view that innovative activities carried out by women receive far fewer services and less support than those carried out by men (Bardasi, Blackden, and Guzman 2007; Ellis, Manuel, and Blackden 2006). These challenges reduce the effectiveness of female actors and affect their general performance.

A number of approaches have been used in examining constraints of target groups. The Kendall's ranking technique may be simple but it is very effective in analyzing constraints faced by a target group (Ofori-Appiah 2018). In this approach, a list of constraints is made available for the target group to assign a rank from the most to the least compelling constraints. As noted by Legendre (2005), KCC is employed in assessing the level of compatibility amongst the ranked constraints. The KCC approach is specified as:

$$KCC = \frac{12\left[\sum R^2 - \left(\frac{\sum R^2}{m}\right)\right]}{mn^2(m^2-1)} \quad (5)$$

where: R = sum of rankings for constraints, n = number of respondents, m = number of constraints ranked.

The estimated value of KCC has a range that lies between zero (0) and one (1). A value of one (1) shows a perfect agreement with respect to the ranked constraints, whilst a value of zero (0) shows the high point of disagreements in ranking amongst the respondents (Ofori-Appiah 2018).

This technique makes it possible for hypothesis investigation to conclude on the agreement involving the rankings by the target group. The f-test or the chi-square test can be considered to validate the agreement. The paper specifies a null hypothesis as H_0: there is no agreement among the ranked constraints by the fishers. The alternate hypothesis is specified as H_A: there is agreement among the ranked constraints by the fishers. The decision rule by this paper is that if $F_{calculated}$ is greater than $F_{critical}$, we reject the null hypothesis (H_0).

Additionally, this method is very appropriate for a group of similar kind or nature who are confronted with the same constraints. The current study employs this

approach since the constraints of homogenous groups (females and males) are analyzed.

Study area and dataset

The research was conducted in the Greater Accra and Central regions in the southern sector of Ghana. The study identified fishing communities and hubs where fish trading and processing are predominant. Using a multi-stage survey technique, 230 fish workers were obtained for the analysis. Fish workers (fishers, traders, and processors) were the target population for the research. Greater Accra and Central regions were purposively selected in the first stage since these are areas where fishing, fish trading, and processing are predominant. The second stage involved a purposive sampling of four major fishing communities and hubs (Figure 2) for fish trading and processing (Tema and Prampram in Greater Accra; and Apam and Winneba in Central region). In the third stage, a list of fish workers in these communities and hubs was obtained from fisheries officers and chief fishermen in these communities where numbers were assigned for random selection.

Tema Metropolis is a coastal district whose proximity to the sea positions it as a natural endowment for a fishing harbour that was established to promote fish marketing. The indigenous occupation of the people is fishing (Ghana Statistical Service – GSS 2014a). Prampram is the capital of the Ningo-Prampram Municipality. The highest proportion of the employed population are fishery, skilled agricultural and forestry workers. The district is bordered by the Gulf of Guinea with a coastline stretching over 37 kilometres. This gives the district a huge potential for fisheries activities (GSS 2014b). Winneba is the municipal capital of the Effutu Municipality. Fishing is seen as one of the major income generating activities in the municipality with 16.1% of the inhabitants relying on fishing, agriculture, and forestry as sources of livelihood (GSS 2014c). Apam is the district capital of the Gomoa West District. Fishing constitutes the main economic activity for the coastal communities which includes Apam (GSS 2014d).

Results and discussions

This section highlights and discusses findings of the paper in terms of qualitative and quantitative impact of the choice of innovation on the income of fish workers. The gendered constraints to innovation identified and ranked are also discussed.

Subjective outcome of fish workers' innovation

Innovators were asked about the outcomes of their innovation choices to understand the impact of innovation from a gender subjective perspective. Their responses are summarized in Figure 3.

Tambo and Wünscher (2016) also found a resembling subjective consequence of the welfare outcome of innovation practices of crop farmers in Ghana. Ntiamoah, Li, and Sarpong (2019) were also of the view that measuring innovative performance in non-financial terms such as increased consumer satisfaction and production speed is necessary. Consistent with Fujii et al. (2018), the result of this current paper shows that income (higher among male fishers – 39% than female fish processors – 34%) is one of the major outcomes of fish workers' innovations. This is possible because most of the other benefits could translate into enhancing income. Increased consumer satisfaction is also another important outcome expressed mostly by the processors – 31% for female fish processors compared to 22% for male fishers. The use of some innovations helped to satisfy consumer tastes and preferences. An example is that retailers who purchased processed fish, especially for export must meet some standards in terms of smoke content. The new ovens introduced to the processors produce less smoke and can meet the preferences of consumers and fish processors can obtain better prices for their fish. Gordon, Pulis, and Owusu-Adjei (2011) confirmed that smoked fish for export is usually prepared and packaged in a visually more attractive way to command higher prices. Another positive effect of the fish workers' innovations is timeliness of operation. This is more visible in male fishers – 27% than female fish processors – 22%. Some of these innovations help to save labour and make fish work less stressful. Male fishers were of the view that the GPS tracker helps them navigate easily during their fishing expeditions. The echo sounder is another innovation that helps the fishers to locate fish easily for a better catch. This is possible because these innovations make it easy for fishers to find and return to good fishing spots (FAO 2012). Innovations such as the racks and ovens also enable drying and smoking a lot of fish at a time, hence making the work of processors faster (FAO 2020). Innovations that save time are particularly essential for women to ensure a good balance between productive work and domestic activities. Increased supply of fish is ranked last among the benefits (male fishers – 17%; female fish processors – 8%) as noted also by Ragasa et al. (2014) and Ndiaye, Sodoke Komivi, and Diei-Ouadi (2015).

Impact of innovation

Results on the impact of choice of innovation on the income of fish workers are summarized and presented in Table 2. The innovation choices have been grouped into two: technological innovation and non-technological innovation, whilst considering no innovation as the base category. The paper therefore estimated the impact of adoption of the two categories of innovations on the income of fish workers. Other exogenous determinants of income are presented in Table 2 as well. The overall model is statistically significant at the 1% level as measured by the probability of the Wald chi-squared estimate. The full estimates of the multinomial endogenous treatment effects model are presented in Table A2 in the Appendix which contains parameter estimates of the mixed multinomial logit model of the choice of innovation in the first stage and the estimates for impact of choice of innovation in the second stage. However, the discussion in this paper focuses on the impact results.

The results also indicate that the choice of technological innovation for fish work (e.g., GPS tracker, echo sounder, 'Ahoto' oven, and FTT – thioarye smoking technology oven) enhances the income of fish workers by

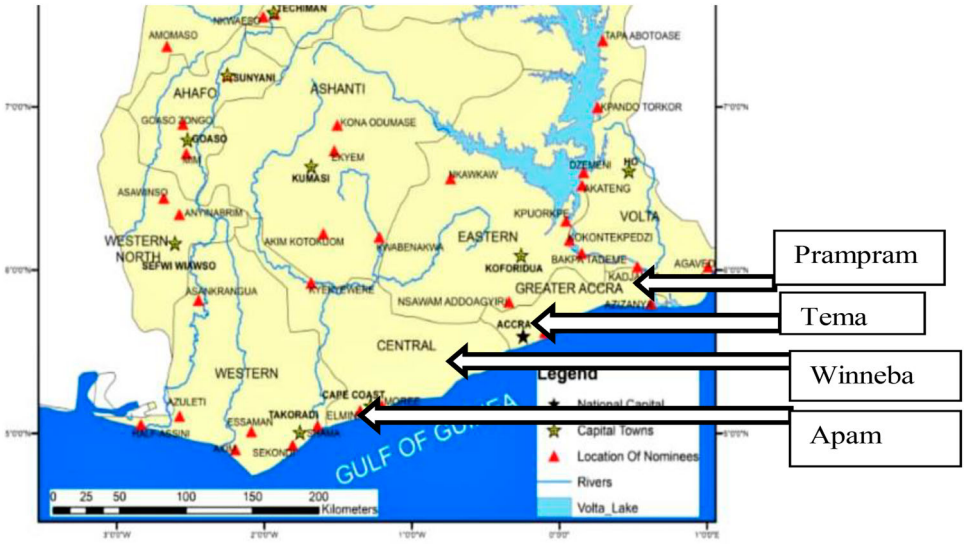

Figure 2: Map of the study area (Geography Department, University of Ghana 2020).

9.92%. Technological innovations have been studied extensively by a number of authors and most of these innovations have been found to yield positive impacts (Khonje et al. 2018 and Nti, Plahar, and Larweh 2002). Findings further reveal that the choice of non-technological innovation (e.g., racks, cases, fishing in nearby seas, and buyer-seller arrangements or networks) for fish work enhances the income of fish workers by 11.84%. The result justifies the advocacy by authors to promote alternative forms of innovation other than technological innovations since these innovations may also be beneficial (Alsos, Ljunggren, and Hytti 2013; Lindberg and Schiffbänker 2013). The paper thus demonstrates that adoption of both categories of innovations is revealed to have positive impacts on the income of fish workers. The percentages obtained are relatively similar in magnitude to the values obtained by Gebremariam and Wünscher (2016) in their study of the adoption of innovations. Studies such as Manda et al. (2016) and Mutenje et al. (2016) also recorded positive impacts of innovations on income. The results also show that gender, education, primary activity, and association membership have negative relationships with the income of fish workers. However, the estimates are not significant with education and primary activity. On the other hand, savings, credit access, and support service are estimated to have positive and significant effects on the income. This section discusses only the variables that have significant effects on the income of fish workers.

The paper reveals that female fish workers obtained lower incomes than male fish workers. The descriptive analysis confirmed this result and revealed that the mean income of male fishers (GHS 14,279.37) is higher than that for female fish processors (GHS 11,482.48).

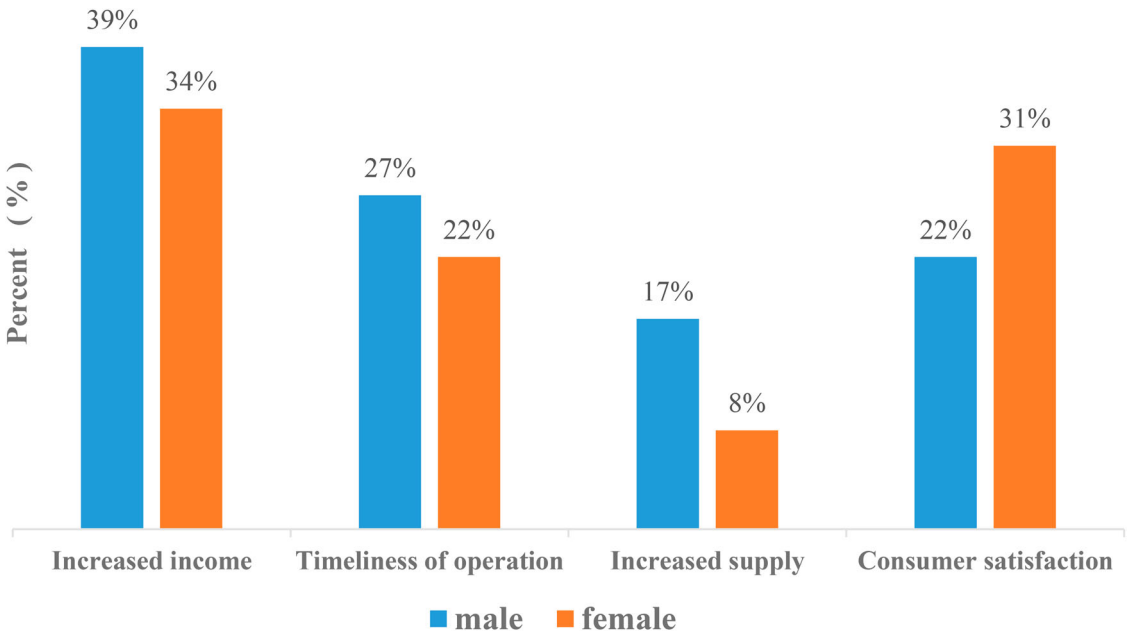

Figure 3: Subjective outcome of fish workers' innovation.

Table 2: Impact of innovation on income.

Variables	Coefficient	Standard error	*P*-value
Non-technological	0.1184***	0.0178	0.000
Technological	0.0992***	0.0109	0.000
Gender	−0.0181*	0.0104	0.081
Education	−0.0136	0.0092	0.137
Savings	0.0224***	0.0837	0.008
Primary activity	−0.0096	0.0070	0.173
Credit access	0.0202**	0.0080	0.011
Association member	−0.0334**	0.0141	0.018
Support service	0.0220*	0.0130	0.091
Constant	−4.3009	0.5493	0.000
Lnalpha	6.5018	0.5493	0.000
lambda_non-technological	−0.0261	0.0647	0.106
lambda_technological	−0.0118	0.0118	0.316
alpha	666.39	366.07	
Number of observations = 230; Prob > chi2 = 0.000; Wald chi2(28) = 293.73; Log pseudolikelihood = −312.9279; *10%, **5%, ***1%			

***Source*:** Field survey (2020)

This result is in line with expectations and consistent with Anang, Bäckman, and Sipiläinen's (2020) findings. It is believed that men normally have greater control and ownership over production assets or resources in Ghana. It is also known that women play other roles in the household aside from their productive activities which limits their time allocation to fish work and hence their income from fish work (Anang, Bäckman, and Sipiläinen 2020). Savings is estimated to have a positive relationship with income at a 5% level of significance. Aghion et al. (2016) suggested that catching up on innovations requires investment; hence, having some domestic savings facilitates the process of using innovations which also may lead to growth of economic activities. Jagadeesh (2015) also stated that accruement of fixed resources is mostly made possible through adequate savings. The study further explained that capital accumulation can enhance the use of technological innovation and progress which assists in economies of largescale production and accelerates the productivity of labour. Hence, savings may result in maximum employment of resources in an effective way to improve the quantity of output size income. This paper revealed that the income of fish workers was enhanced due to access to credit. The findings of Anang, Bäckman, and Sipiläinen (2020) also showed that credit plays an important role in ensuring timely acquisition of inputs and optimum production thereby enhancing income. Sesabo and Tol (2005) also recognized the significant role credit plays in increasing the income and productivity of fish workers and demonstrated that households that have no credit constraint are more capable of investing in fishing activity. However, households that are credit constrained are forced to reduce their participation in fishing activities which resulted in observed differences in fishing income of these two groups of fishers.

The paper also estimated that fish workers who belong to an association had lower income from their fish work. Di Falco and Bulte (2013) suggested that social networks can bring about unexpected outcomes that may bring about free-riding and eventually limit motivation to adopt innovations. Group focus may also not be geared towards adoption of innovations but may have other objectives and a different vision for its members. Members may need additional support services to ensure that innovations are being used effectively to enable optimum outcomes. The result further indicates that farm income increases with access to support services such as innovation training. This is in line with expectations since support service may come in the form of agents from whom workers obtain information on innovations and modern productive practices. Workers learn about improved technologies that increase productivity and income from these agents (Mabe et al. 2018). OECD (2005) also suggested that training in the use of modern technologies and programmes to improve skills and capabilities are necessary in the promotion of innovation to enable workers to take advantage of innovations and ensure the success of their operations.

Gendered constraints to innovation

The paper identified six gendered constraints to innovation whilst drawing on Badstue et al. (2018) and Ragasa et al. (2014) and through pre-field interactions. These are constraints that affect the ability of both men and women to adopt, implement and benefit from and make decisions around innovations. The most pressing constraints identified by female workers include cultural/ethnic restrictions, social exclusion, and time constraints. The most pressing constraints facing male workers include a high dependency ratio, discrimination in access to resources, and social exclusion (Table 3).

From the results, 64% of the female fish workers and 71% their male counterparts agreed on the ranked constraints. The asymptotic significance with the value of 0.000 suggesting a null hypothesis of no degree of agreement involving the fish workers was rejected in favour of the alternate hypothesis. This suggests that the fish workers agreed on the ranked constraints as seen in Table 3. Cultural/ethnic restriction is ranked first by females and sixth by males. Cultural/ethnic restrictions exist in the form of social norms which mostly put women in disadvantaged position. Social norms are the accepted ways of doing things in a society and these standards may dictate how males and females are trained. Social norms may prevent women from having access

Table 3: Rank of constraints to innovation facing female and male fish workers.

Constraints	Mean rank: Female	Rank: Female	Mean rank: Male	Rank: Male
Cultural/ethnic restrictions	1.79	1	5.24	6
Social exclusion	2.25	2	3.11	3
Time constraints	2.98	3	3.76	4
Spousal/partner obligations	3.39	4	5.22	5
Discrimination in access to resources	5.28	5	2.44	2
High dependency ratio	5.31	6	1.24	1
N	125	N	110	
Kendall's Wa	0.640	Kendall's Wa	0.711	
Chi-square	400.039	Chi-Square	391.122	
Df	5	Df	5	
Asymp. Sig.	0.000	Asymp. Sig.	0.000	

***Source*:** Field survey (2020)

to education or higher levels of education as noted by Khonje et al. (2018) and this may affect their level of adoption of innovations. The difference in ranking is influenced by the prevalence of cultural norms and social biases that limit opportunities and equal access for women and men with women mostly being in the disadvantaged position (Ragasa et al. 2014).

Social exclusion is ranked second by females and third by males. Women in these areas are mostly excluded from participation in social gatherings. Exclusion of women is sometimes indirect and unintended because they may not be able to meet certain requirements (e.g., financial and time requirements) which indirectly excludes them from joining these groups (Ellis, Manuel, and Blackden 2006). The men on the other hand complained about the lack of bottom-up approaches towards decision-making. Hence, this situation excludes them from making very important decisions concerning innovation resources. Time constraints was ranked third by males and fourth by females. Time constraints may prevent women from participating in activities or joining groups which may facilitate adoption and use of innovations. Pender and Gebremedhin (2008) noted that women are inclined to adopting improved technologies at a slower pace than their counterpart men due to time constraints. Men are considered as bread winners, hence their engagement in productive activities for long hours is considered normal while the engagement of women in productive activities is often part-time and mostly viewed as helping out (D'Agnes et al. 2005). Spousal or partner obligation was ranked fourth by females and fifth by males. This means that mutual understanding between partners for coexistence is not seen as a hindrance for adoption of innovation to enhance economic gains. Béné et al. (2016) noted that women fish processors in the western region of Ghana usually support their spouses financially during hard times to enhance their fisheries activities.

Discrimination in access to innovation resources is ranked second by males and fifth by females. Access to innovation resources (e.g., credit, information, and inputs) makes it easier to adopt innovations. Sharing of scarce resources led to some fishers being left out unreached. Additionally, difficulty in accessing credit prevents these fishers from acquiring the needed innovation. Females had similar concerns when it came to the scarce innovation resources but they managed the situation by sharing the little that is available (e.g., the 'Ahoto' oven) among themselves. Hence, females ranked these constraints lower than males. High dependency ratio is ranked first by males and sixth by females. High dependency ratio is a challenge due to the high number of people that male fish workers must support financially. The burden of financial obligations mostly falls on the men since men are seen as the primary breadwinners (Brickell and Chant 2010), while women are mostly considered as playing supporting roles (D'Agnes et al. 2005). According to GSS (2014a), the average dependency ratio in the study area is quite high and may worsen the plight of these fishers.

Conclusion

This paper uses the multinomial endogenous treatment effect approach to analyze the impact of the choice of innovation on the income of fish workers. In addition, Kendall's ranking technique is employed to analyze the constraints on innovation. The results show that increased income, timeliness of operations, increased supply and consumer satisfaction are some outcomes of fish workers' innovation. The results also reveal that technological innovation and non-technological innovation available to fish workers have positive impacts on income of fish work (higher among male fishers than female fish processors). Savings, credit access, and support service have positive impacts on income while gender and membership of a fish workers' association have negative impacts on income. The most pressing constraints on innovation faced by female fish workers are cultural/ethnic restrictions, social exclusion, and time constraints. On the other hand, high dependency ratio, discrimination in access to resources, and social exclusion are the most pressing constraints faced by male fish workers.

Based on the conclusions, the paper recommends that stakeholders should continue to offer support services in the form of training, credit, information, and other innovation resources. These programmes should be designed and made flexible to ensure access by women due to their time constraints. Lending institutions should make credit, with flexible terms of repayment, more accessible to fish workers since access to credit has a positive impact on income. Fishery officers should also inculcate the

culture of saving among fish workers since saving can help them purchase some innovation resources on their own and enhance their income. Interventions by MoFAD and development agencies that aim to solve constraints of fish workers should be tackled from a gender dimension to yield their potential impact since constraints differ for males and females. More focus on gender analysis and gender-disaggregated data for research is necessary.

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