Subsidies – help or hurt? A study from Vietnamese fisheries

Thuy Thi Thanh Pham[12*], Ola Flaaten[2], Luong Trong Nguyen[3], Nghiep Ke Vu[3]

[1] Faculty of Economics, Nha Trang University, Vietnam

[2] Norwegian College of Fishery Science, UiT The Arctic University of Norway, Norway

[3] Institute of Marine Technology, Nha Trang University, Vietnam

[*] Corresponding author, thanhthuypt@ntu.edu.vn; thanh.thuy@uit.no

Pham Thi Thanh Thuy is a postdoctoral research fellow, Norwegian College of Fishery Science, University of Tromsø, 9037 Tromsø, Norway (email: thanh.thuy@uit.no).

Ola Flaaten is professor emeritus, Norwegian College of Fishery Science, University of Tromsø, 9037 Tromsø, Norway (email: ola.flaaten@uit.no).

Luong Trong Nguyen is a researcher, University of Nha Trang, 02 Nguyen Dinh Chieu, Nha Trang, Vietnam (email: luongnt@ntu.edu.vn).

Nghiep Ke Vu is a researcher, University of Nha Trang, 02 Nguyen Dinh Chieu, Nha Trang, Vietnam (email: nghiepvk@ntu.edu.vn).

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ABSTRACT

Subsidies are part of the set of management tools that governments apply to modernize their fishing fleets and enable them to engage in offshore and international fisheries. Research has shown that subsidies often lead to overcapacity and overfishing, resulting in the depletion of fish stocks. A few studies have, however, found some positive effects for particular subsidies. In this paper, we investigate a credit-linked subsidy scheme in Vietnam, which seems to be justified on the basis of economic, social, and environmental considerations. Both propensity score matching and endogenous switching regression methods are employed for analysis. The results show that the subsidies have had a positive effect on fishermen's profitability, mainly due to increased revenue rather than cost reduction. However, the subsidies have benefited only the owners of the biggest vessels, and inefficiency in subsidized vessels may threaten resources and profitability in the long term.

KEY WORDS: *capacity enhancing subsidies, sustainability, endogenous switching regression, propensity score matching.*

JEL CODES: C31, D01, Q22, Q28.

INTRODUCTION

Fisheries subsidies are widely recognized as a government failure in many countries because they are a driving factor in building up excessive fishing capacity, which leads to overfishing (e.g., Milazzo 1998; OECD 2000; Munro and Sumaila 2002; Flaaten 2021). Overfishing, in turn, negatively impacts the food security and livelihoods of vulnerable coastal communities. Subsidies can also exacerbate existing inequalities in the sector in terms of access to and control over fisheries resources. In 2009, the subsidies granted to fisheries worldwide were estimated at USD 35 billion, of which USD 20 billion were categorized as capacity enhancing (Sumaila et al. 2019). This was a waste of money, according to Arnason, De Fontaubert, and Kabayashi (2017), who have called for a major reform of existing fisheries policies.

Despite these concerns, many governments, especially in developing countries, still use fisheries subsidies as a management tool, as this is an important economic sector, and governments want to increase catches and revenues by targeting species and fishing grounds that are not yet fully exploited. Since the 1982 UN Convention on the Law of the Sea (UNCLOS), it has also become especially important for many coastal states to mark their ownership of and control over the resources of the entire exclusive economic zone (EEZ) they claim. This is a particularly pressing issue in the South China Sea (SCS), where no agreement on maritime boundaries has been settled. Many of the littoral states have therefore sought to strengthen their presence in disputed areas by subsidizing their own fleets. Although capacity-enhancing subsidies have been criticized as a major cause of fish stock depletion in the long term, the governments have several goals to consider, which may justify the use of subsidies.

This paper investigates the 2014 fisheries subsidy in Vietnam as a specific case and analyze the economic, social, and environmental effects of the subsidy scheme. The 2014 scheme offered inexpensive loans to fishermen who wanted to build larger and more modern vessels. It was hoped this would stimulate a shift from inshore to offshore fisheries, reduce the pressure on inshore resources, give access to more abundant offshore resources, increase harvest and profitability, and bolster national sovereignty in disputed border areas. The main objectives of this paper are threefold: first, to clarify who has taken advantage of the opportunity to receive government subsidies. Who are the beneficiaries? Second, to examine whether subsidized vessels are more profitable than non-subsidized vessels, and if so, is this due to input reduction, output increase, or both? Third, to investigate if there has been any inefficiency in the subsidized vessels that is likely to undermine the sustainability of fishing in the long term.

There is an extensive literature evaluating the effects of subsidies in fisheries, but empirical studies on this topic are still scarce, primarily due to limited data. Consequently, it is difficult to accurately define the positive and negative outcomes of subsidies for fisheries and under what conditions to expect the different outcomes. This paper uses collected vessel data and contributes to filling the knowledge gap that exists in the empirical evaluation of participation in offshore subsidy schemes. We employed both propensity score matching (PSM) and endogenous switching regression (ESR) in the analysis. The former is a non-parametric method whilst the latter is a parametric approach. Also, although both methods are able to deal with selection bias, ESR takes both observed and unobserved factors into account when estimating the impact of subsidy scheme but PSM does not account for unobserved effects. To the best of our knowledge, these two methods have not been used widely in fisheries studies. Exceptions are the work by Pham, Flaaten, and Anh (2013); Salazar (2015); Nguyen and Flaaten (2016); and Salazar and Dresdner (2020). Unlike these studies, however, we employ the two methods simultaneously, which allows us to check the validity of the results and gain a comparative perspective. Furthermore, rather than focusing on one particular fishery (e.g., Nguyen and Flaaten 2016 studied gillnet fishery), we take advantage of the richness of the data and consider different fisheries to explore the divergence across fisheries. We also attempt to take into account contextual factors—such as having sufficient capital and perceptions of the application process to obtain subsidies—when investigating decision-making behavior concerning whether or not to participate in the subsidy scheme. These aspects have not received much attention in previous studies of fisheries subsidies.

The findings of the paper show that subsidies both help and hurt the fishing industry. First, they enhance the profitability of fishing, at least in the short run. This is mainly driven by increased revenue due to better technology and opportunities to access fishing grounds with more abundant fish stocks, rather than reduced vessel costs from subsidies. Second, by motivating fishermen to build larger vessels that can go fishing offshore, subsidies help demonstrate sovereignty and presence in disputed areas. This may be important for future negotiations with neighboring countries on national EEZs and the sharing of straddling and highly migratory stocks. Nevertheless, there are indications of inefficiency in the subsidized vessels, which suggest that unsustainable fisheries will occur in the long term if the fisheries remain open access and the subsidy scheme is maintained. The scheme also has non-intended distributional effects. Instead of increasing the incomes of the vast majority of small-scale fishermen, it has mainly benefited the owners of the largest vessels.

The rest of the paper is organized into six sections. First, we provide a literature review about fisheries subsidies in general and for specific cases. Next, the fisheries sector in Vietnam is described and the main characteristics of the 2014 subsidy scheme is briefly outlined. After that, we introduce the methods, data used, and the results obtained using the two different methods of analysis. Finally, the main findings are summarized and discussed.

LITERATURE REVIEW ON FISHERIES SUBSIDIES

Theoretical studies

The Gordon-Schaefer model is regarded as the first theoretical explanation of the biological consequence of a subsidy scheme. This is a comparative static single-species model based on the assumptions of logistic biological growth, constant price, and constant unit cost of effort. The model has a bio-economic equilibrium where total revenue is equal to total cost. When policy makers engender higher fish prices or lower costs by the use of subsidies, the fishing effort will expand with a negative effect on the fish stock[i]. Declining catches will follow, and the result is a lower equilibrium resource stock.

However, most actual fisheries are not pure open access fisheries, and there is no static equilibrium as simple bio-economic models assume. Therefore, Munro and Sumaila (2002) took a further step by discussing the impacts of subsidies in the case of a sole owner fishery and under the assumption of a dynamic equilibrium. The main conclusions were the same as in the Gordon-Schaefer model. The impacts are further complicated when fishermen’s labor–leisure choice is taken into consideration. Here, the fish stock may decrease if subsidies are removed and fishermen respond by spending more time on fishing to offset the reduction in income- or price-support subsidies (Jinji 2012).

While most papers have discussed the impacts of subsidies on domestic fish stocks, some papers have focused on shared fish stocks and explained the use of effort subsidies within a two-country model (e.g., Ruseski 1998; Quinn and Ruseski 2008). The model shows that by providing effort subsidies, a country with a cost advantage can make the vessels of the other country stay away from the shared areas due to zero profit. However, a cooperative solution can escape the subsidy trap and is even very profitable for all countries fishing on shared resources (Armstrong and Flaaten 1991; Long and Flaaten 2011; Munro 2017).

Empirical studies

One of the prerequisites for conducting empirical research is available data. For decades, international organizations such as the WTO, FAO, and OECD have discussed subsidy issues and collected subsidy data among their member countries. These data have been used by many researchers for important empirical publications (e.g., Yagi, Senda, and Ariji 2008; Sumaila, Dyck, and Cheung 2013; Sakai 2017). Surveys are another data source (e.g., Nguyen and Flaaten 2016 for Vietnamese fisheries) or data collected directly from national or local agencies (e.g., Yagi, Ariji, and Senda 2009; Schachermayer et al. 2011). A noteworthy study done by Sakai, Yagi, and Sumaila (2019) provides a nice overview of existing studies, both theoretically and empirically, on fisheries subsidies and discusses their roles in the policy-making process.

The general conclusion of the empirical studies is that subsidies are building up excessive fishing capacity, which, in turn, leads to overfishing in cases of poor management (e.g. Milazzo 1998; OECD 2000; Munro and Sumaila 2002). Subsidies can also result in economic waste and welfare loss (e.g., Cox and Sumaila 2010; Arnason, De Fontaubert, and Kabayashi 2017), exacerbate inequities (e.g., Cisneros-Montemayor and Sumaila 2019; Smith 2019), and render livelihoods that depend on them unsustainable (WWF 2001). Nevertheless, not all subsidies are harmful to resources, the economy, and society. Instead, the effect of subsidies must be assessed in relation to specific goals, the type of subsidy, the management regime, and the state of the fish stocks. For example, subsidies that support research and monitoring and promote resource conservation and management are expected to lead to improved outcomes (Milazzo 1998; Flaaten and Wallis 2001; Grafton et al. 2006). Subsidies in the form of direct payments, cost reducing transfers, and general services can increase both the input and the output of fisheries (Yagi, Senda, and Ariji 2008; Yagi, Ariji, and Senda 2009). Increased output is also observed for fuel support schemes, but this might erode over the years (Nguyen and Flaaten 2016). Furthermore, the size of the subsidy does not determine the fisheries outcome (Schachermayer et al. 2011).

Currently, the number of empirical studies on fisheries subsidies is still scarce due to limited data (Schachermayer et al. 2011; Sakai, Yagi, and Sumaila 2019). It is thus difficult to identify clearly which subsidies are effective or ineffective in which fisheries, as well as what would happen without subsidies. This paper relies on own vessel data and contributes to filling the knowledge gap that exists in the empirical evaluation of participation in subsidy schemes. Our study is in line with Yagi, Senda, and Ariji (2008); Yagi, Ariji, and Senda (2009); and Nguyen and Flaaten (2016) regarding the hypothesis that subsidies increase output of the fisheries, but differ with respect to the type of subsidy. While they focus on direct payments, cost-reducing transfers, general services, and fuel subsidies, we consider boat construction and modernization subsidies that are very common in SCS-bordering countries. In addition to measuring the impacts of subsidies on economic performance per vessel, impacts per horsepower (HP) are also investigated. Profit per HP in this study is used as a proxy of return to capital and to measure efficiency of the subsidized vessels (Pascoe and Gréboval 2003). We use PSM, which was introduced by Rosenbaum and Rubin (1983), and the ESR technique, which was developed by Lee (1982), to estimate causal effects of subsidy adoption. These two counterfactual evaluation methods have rarely been used in the context of fisheries (Sakai, Yagi, and Sumaila 2019).

THE FISHERIES SECTOR IN VIETNAM AND THE 2014 SUBSIDY SCHEME

Vietnam has a coastline of 3,260 km and an EEZ of about one million km^2 (FAO 2005). Its coast has diverse marine resources with more than 2,000 species of fish, of which about 130 species have commercial value and 30 species are regularly exploited by capture fisheries (Nguyen 2017). With the abundance of marine resources and high economic value species, the fisheries sector plays an important role in securing food and promoting economic development in Vietnam. Fish is a central component in the traditional diet and accounts for about 40% of the protein supply (Son and Thuoc 2003). In 2020, the sector constituted 5% of gross domestic product and provided jobs for approximately 4 million people (VASEP 2020).

The Vietnamese fisheries are characterized by open access. Traditional modes of artisanal production and technologically backward capture still dominate. In 2018, there were approximately 109,000 fishing vessels, of which 69% had an engine with less than 90 HP, which were operating in the near-shore areas (D-FISH 2019). Most fishing vessels are made of wood. Recently, there has been a shift from demersal to pelagic fisheries. Pelagic fisheries are multispecies, with mackerel and tuna being dominant. The most common fishing gear is the gillnet (36% of vessels), followed by trawl (19%), hook and line (18%), purse seine (5%), pushnet (2%), and others (20%) (D-FISH 2019). Although Vietnam, with its open-access fisheries regime, stands out as one of the world countries with the highest harvest growth, it is clear that this growth has slowed down in recent years (Flaaten 2013). In 2014, around 43% of the fish stocks within the EEZ were estimated to be fully exploited, 3% overexploited, and 5% had collapsed (Harper and Sumaila 2019). This indicates that the fisheries have reached the limit to growth and that overfishing in inshore waters may be imminent.

The 2014 subsidy scheme offered fishermen favorable loans to build or modernize their vessels. The loans were arranged through commercial banks, which were instructed by the government and received the difference from the normal market interest rate covered by the state. To obtain the loan, the fishermen had to apply to the provincial fisheries department, document efficient fishing activity in the previous years, prove that they had sufficient capital, and present a clear plan for future fishing. The government could support 70%–90% of the investment capital, depending on the engine capacity of the vessel, while the rest had to be funded by the vessel owner. After receiving the subsidy, the vessels should have an engine of at least 400 HP and target pelagic species. The government had aimed for 2,079 vessels to have received support by the end of 2017, but at that time only half as many had had their applications approved. The subsidy scheme was prolonged in 2018 with some amendments.

METHODOLOGY

The issue of selection bias is often raised in evaluation studies. Measuring the effects of the 2014 subsidy scheme can be seen as a specific case of the general selection bias problem. To determine the true effect of the subsidy scheme on a particular vessel owner, we must compare the observed outcome with the anticipated outcome if the fisherman had not participated in the scheme. However, not all fishermen will be interested in participating in the subsidy scheme, which leads to biased estimates if unwilling fishermen are excluded. Fishermen who do participate in the subsidy are a subset of the total number of sampled individuals, leading to a non-randomly selected sample from the entire set of fishermen. Selection bias may arise when the observations selected are not independent of the outcome variables. Ruling out fishermen who are not willing to participate, the data are censored, and the sum of residuals is no longer zero as expected. This would result in inefficient, inconsistent, and biased parameter estimates in the regression model analyzed based only on the sub-sample. Given that the majority of the vessels sampled were not subsidized (see Table 1), the empirical specification must be able to incorporate this initial decision on the part of the fishermen correctly. Drawing conclusions for the entire population, as well as the subpopulation from which the effects were solicited, we used both PSM and ESR methods to investigate the decision variable.

Propensity score matching method

PSM is a non-parametric approach and thus does not require that a functional form and distribution assumptions be specified. Its basic idea is to match observations of adopters and non-adopters according to the predicted propensity of adopting a superior regime and then to compare the observed outcomes of the adopters with those of the non-adopters (Rosenbaum and Rubin 1985; Heckman, Ichimura, and Todd 1997; Wooldridge 2002). The matching procedure creates the conditions of a randomized experiment to evaluate the causal effect as if in a controlled experiment.

To determine the factors associated with subsidy participation decisions, it is assumed that voluntary decisions for participating in a subsidy scheme depend on the expected benefit. Specifically, involvement in a subsidy scheme is expected to lead to higher revenue, lower cost, and therefore higher profit. A general model is thus presented wherein fisherman *i* contemplates whether or not to participate in a subsidy scheme based on the information available at the time of the decision:

$$I_i = \alpha Z_i + u_i \tag{1}$$

where Z_i is the vector of individual-specific and observable variables that might affect the decision. These variables could be the demographic attributes of fisherman *i*, attributes of human capital,[ii] attributes of physical capital,[iii] and attributes of finance capital;[iv] u_i is the random error.

The decision of fisherman *i*, I_i, is defined as being equal to 1 if the fisherman decides to participate and is equal to 0 otherwise. Associated with each decision is an expected benefit. If one could observe the treated and control states, the treatment effect, τ, would equal $Y_i(1) - Y_i(0)$, where $Y_i(1)$ equals the potential outcome of the vessel *i* with subsidies and $Y_i(0)$ that of the vessel without subsidies. However, either $Y_i(1)$or $Y_i(0)$ are observed for each vessel. To solve this problem, individual vessels are randomly assigned to either the subsidized or nonsubsidized group and then an unobserved counterfactual is constructed using the randomly assigned nonsubsidized or subsidized vessels. Hence, the average treatment effect on the treated group (ATT) can be obtained using the following equation:

$$ATT = E(Y(1)|I = 1) - E(Y(0)|I = 1) = E\{E\big(Y(1)|I = 1, P(Z)\big) - E\big(Y(0)|I = 0, P(Z)\big)|I = 1\} \tag{2}$$

where $E\big(Y(0)|I=0,P(Z)\big)|I=1)$ is the expected unobserved outcome of the subsidized vessels. In other words, it is the mean constructed counterfactual using the matched non-subsidized and subsidized vessels with the same propensity scores.

However, the validity of the PSM method rests on two assumptions: (1) the conditional independence assumption (CIA) and (2) the common support condition (CSC). CIA requires that Z must include all of the factors that affect both the decision to participate in the subsidy scheme and the outcome. By matching the subsidized vessels with the non-subsidized vessels with similar estimated propensity scores, we controlled for the effect of these factors on the outcome. CSC makes it possible to ensure a positive probability of being in both subsidized and non-subsidized vessels and a sufficient overlap in the characteristics of the two groups. Given that CIA and CSC are satisfied, the impact of the subsidy scheme on the outcome can therefore be averaged across the vessels.

Endogenous switching regression method

The drawback of the PSM technique is that it can only overcome the selection bias caused by observables. When endogeneity is caused by unobserved heterogeneity, the results will be biased. In the context of this study, there may be systematic differences in the outcomes between subsidized and non-subsidized vessels even after conditioning, because selection is based on unmeasured characteristics (Smith and Todd 2005). To overcome this problem, we employed an ESR model that accounts for both observed and unobserved sources of bias (Lokshin and Sajaia 2004; Shiferaw et al. 2014; Ma and Abdulai 2016) by estimating the selection and outcome equations simultaneously using the full information maximum likelihood (Lokshin and Sajaia 2004; Ma and Abdulai 2016).

The ESR model consists of two stages. In the first stage, a fisherman participates in the subsidy scheme based on the expected benefit. The benefit depends on both the observable characteristics, as in PSM model, Z_i, and unobservable characteristics, u_i^d. This is formulated in the selection equation:

$$I_i = \alpha Z_i + u_i^d \tag{3}$$

Given that fishermen choose to either participate or not participate in the subsidy scheme, the observed benefits take the following values:

Regime 1 (subsidized vessels): $Y_{1i} = \gamma_1 X_{1i} + \varepsilon_{1i}$ if $I_i = 1$ (4)

Regime 2 (non-subsidized vessels) : $Y_{0i} = \gamma_2 X_{2i} + \varepsilon_{2i}$ if $I_i = 0$ (5)

where X_i represents a vector of variables that affect the expected outcomes from participating in the subsidy scheme; ε_i is the error term; and Y_{1i} and Y_{0i} are the outcomes (profit per vessel, profit per HP) of the i^{th} subsidized and non-subsidized vessels, respectively.

Another feature of the ESR method is that it assumes a non-zero correlation between the variance of the error term of the selection equation, σ_u^2, and the variance of the error terms of the outcome equations for subsidized and non-subsidized vessels, σ_1^2 and σ_0^2, respectively. The three variances are assumed to have a trivariate normal distribution with mean vector zero and the following covariance matrix:

$$\Sigma = \begin{bmatrix} \sigma_u^2 & \sigma_{u1} & \sigma_{u0} \\ \sigma_{u1} & \sigma_1^2 & 0 \\ \sigma_{u0} & 0 & \sigma_0^2 \end{bmatrix}$$

The terms σ_{u1} and σ_{u0} are the covariance between the selection equation and the outcome equations with subsidized and non-subsidized vessel groups.

The change due to the decision to participate (or not participate) can be specified as the difference between the expected observed outcome and the expected unobserved outcome for the treated Y_{1i}. The estimate is called average treatment effect of the treated, ATT, and obtained via the equation below:

$$ATT = E(Y_{i1}|I = 1) - E(Y_{i0}|I = 1) = X(\beta_1 - \beta_0) + (\sigma_{u1} - \sigma_{u0})\frac{\emptyset(\alpha Z_i)}{\Phi(\alpha Z_i)} \quad (6)$$

where the term $\frac{\emptyset(\alpha Z_i)}{\Phi(\alpha Z_i)}$ is known as the inverse Mills ratio. If the estimated coefficient is significant, this suggests that selection bias is present.

The ESR model, however, also has its limitations. First, the model relies on joint normality assumption of the error terms in the binary and continuous equations. Second, at least one instrument variable that affects the participation in the scheme but not the outcome is required. This would help correct for potential endogeneity problems in the model due to unobserved factors. Here, we have chosen “application process,” defined as how complicated the fishermen perceive the application process to be, as a potential instrument. This instrument is categorized as two dummy instrument variables “complicated application process” and “simple application process”. While these variables are expected to affect the decision to participate in the scheme, they should not affect the economic performance of the fishing vessels. The reasons for choosing application process related variables are elaborated in the next section, and the necessary tests are also performed to examine the validity of the identified instrument variables.

Finally, it should be stressed that, in both ESR and PSM, only variables that are influenced by participation or anticipated participation should be included in the model. Therefore, variables that are unchangeable over time or measured before participation are normally recommended (Caliendo and Kopeinig 2008; Nguyen and Flaaten 2016).

DATA AND CHOICE OF VARIABLES

We conducted a survey during 2017 in four coastal provinces in central Vietnam: Nghe An, Phu Yen, Quang Ngai, and Khanh Hoa. These provinces have a long history of fisheries development and include a variety of fishing vessels and local residents with different preferences. The cross-sectional data were obtained via a structured questionnaire designed specifically to gather information through face-to-face interviews. We interviewed 365 vessel owners, mostly in their homes, representing 10% of all vessels in the four provinces eligible for the subsidy scheme. Of these, 262 non-subsidized vessels were collected through the stratified sampling method. The stratified sampling method was not employed for 103 subsidized vessels as these were all the subsidized vessels in operation at that time. The data comprise information on the socioeconomic characteristics of the fishermen, the characteristics of their vessels and fishing operations, associated costs and earnings, and other contextual factors. The distribution of vessels surveyed among the provinces is shown in Table 1.

[Table 1]

The variables used in the study were selected based on focus group discussions with key stakeholders and a literature review, which included, among others, Pham, Flaaten, and Anh (2013); Salazar (2015); Nguyen and Flaaten (2016); and Salazar and Dresdner (2020). Descriptions of the variables are presented in Table 2. The considered outcomes affected by participation in the subsidy scheme are annual profit from the fishing operation per vessel and per HP. Profit is measured as the difference between revenue and total cost of inputs. The inputs consist of expenses for fuel, lubricants, ice, and provisions; repair and maintenance costs; insurance; labor costs; and interest payment on loans.

A number of independent variables are considered to affect both the economic performance and the decision to apply for a subsidized loan. We expect that the variables “level of education” and “experience of the vessel owner” will influence participation in the subsidy scheme. More experienced and better educated vessel owners can govern fishing efficiently, resulting in a greater catch, and therefore they might be interested in participating in the scheme. The variable “own capital” refers to whether the vessel owner has sufficient capital on his own to cover what he needs in addition to the loan from the bank[v]. Those who face own capital constraints will have limited opportunity to participate in the subsidy scheme. As revenue will be affected by fishing technology, this is taken into account by different types of fishing gear, represented by a series of dummy variables for, particularly, purse seine, pushnet, gillnet, and longline technologies.

The application process is generally regarded as an important contextual factor (e.g., Christensen et al. 2011), and in this case, the success of the scheme clearly depends on the willingness of the fishermen to apply for the subsidized loans and to invest in more modern vessels. The instrument variables “complicated application process” and “simple application process” refer to the respondents’ perception of the application process itself—that is, how difficult it is to handle[vi]. This contextual factor tends to be influenced by individual abilities and relevant contacts. If individual abilities and contacts also affect the fishery outcomes, the application process cannot be treated as an independent instrument variable. However, we believe that there is good reason to distinguish between the ability to handle paperwork and applications, and the ability to catch fish. Indeed, the many hurdles associated with the application process itself were strongly emphasized during the focus group discussions. There were many formal requirements that had to be met to receive loans, and the management of the subsidy scheme was different in the different provinces. The commercial banks were also reluctant to provide loans, despite the public subsidies. The banks were unsure whether the fishermen would repay the loans, and they demanded that the fishermen take out insurance for the banks’ security—namely, the vessels. The insurance companies, for their part, were reluctant to sell insurance because they were afraid that the vessels could get lost at sea. They therefore tried to delay the process to discourage applicants. According to the fishermen, there was a lot of paperwork, and several fishermen complained about corruption in connection with loan approvals. As fishermen are normally low educated people, dealing with the paperwork and the administrative procedures was quite challenging for them.

It may be argued that the fishermen's perceptions of the application process and sufficient own capital may have been influenced by the observations they made of subsidized vessels in operation. We collected our data in 2017, but the scheme was launched in 2014. However, the whole process took time. It usually took a year for the application to be approved, which needed to occur before construction or refitting of vessels could begin. The 103 subsidized vessels that we sampled were actually the total population of subsidized vessels in the four provinces in 2017, and most of them had been in operation just about a year. The vessel owners also knew well the investment amount required to join the program, and they could evaluate themselves whether or not they had sufficient own capital. In the face-to-face interviews with the nonsubsidized vessel owners, it was made clear that the time considered was at least one year before the survey (i.e., early 2016). This suggests that possible causal effects from already granted subsidies or crowding out effects as a result of the public subsidies are unlikely.

[Table 2]

Table 2 compares the main characteristics and economic performance of subsidized and non-subsidized vessels. The table highlights that the subsidized (treated group) and non-subsidized vessels (control group) are quite similar in terms of education and experience, but are clearly different with respect to engine power (i.e., the 400 HP requirement). Subsidized vessels tend to have higher revenue and profit per vessel, but per HP the revenue and profit are lower than for non-subsidized vessels. 50% of the respondents characterize the application process as complicated, 34% as simple, while 16% have no clear opinion on this matter. 59% of the owners of subsidized vessels evaluate the subsidy application process to be simple whereas the corresponding number for non-subsidized vessels is 24% only. The owners of subsidized vessels also generally have sufficient capital on their own to participate in the program. Because the subsidized vessels are rather large in terms of engine power, the cost spent for operation is thus also greater than for non-subsidized vessels.

RESULTS

Determinants of participation in the subsidy scheme

The factors that determine whether or not fishermen participate in the subsidy scheme are presented in Table 3 for PSM and Table 4 for ESR. As shown in both Table 3 and Table 4, most of the variables are statistically significant. The significant coefficient for the experience variable confirms that experienced fishermen are more willing to take investment risks, as expected. The variable education is insignificant, which implies that good knowledge and better skills does not make the fishermen more eager to take out loans and invest in bigger vessels. Profitability expected are different among the type of fishing gears; therefore the likelihood of participating in the scheme for those owners who operate purse seine are higher than longline, gillnet and pushnet. The own capital variable is clearly an important deciding factor in motivating fishermen to participate in the scheme. Fishermen without sufficient capital on their own can also be eager to participate, but they are excluded in practice. Fishermen who find the subsidy application process complicated are less likely to take part in the scheme, whereas those who find it simple are more eager to join.

[Table 3]

[Table 4]

Determinants of economic performance

The results regarding the impact of participation on profit per vessel and per HP are presented in Table 4 in the outcome equations for subsidized and non-subsidized vessels. The difference in the coefficients of the explanatory variables in the outcome equations of subsidized and non-subsidized vessels illustrates the presence of heterogeneity in the sample (Di Falco, Veronesi, and Yesuf 2011). Some of these explanatory variables have heterogeneous effects on the profit of the two vessel groups. Among the four types of fishing gear that can generate more profit for subsidized vessels, purse seine tends to be the most attractive, followed by pushnet, longline and gillnet. Having sufficient own capital does not have significantly positive effect on the profit of subsidized vessels. This probably reflects that higher investments also imply higher depreciation costs, which leads to lower profit. The same variables with slightly different impact levels are also found for the profit per HP outcome equations.

The likelihood ratio tests for the joint independence of the outcome equations (i.e., profit per vessel, profit per HP) are statistically significant, indicating that the selection and the outcome equations are dependent on each other. The significant correlation coefficient σ_{u0} indicates the presence of self-selection in participation of subsidy scheme. The factor σ_{u0} is negative, suggesting that the selection bias is positive and that fishermen who choose not to participate in the subsidy scheme will have a higher profit than what a random individual in the sample would have achieved. Insignificant correlation coefficient σ_{u1} implies that participating in the subsidy scheme would not be better off or worse off for nonsubsidized fishermen if they decide to participate. In other words, the profit is the same for the two vessels groups caused by unobservable factors. Since $\sigma_{u0} > \sigma_{u1}$, this suggests that subsidized vessels obtain higher profit than they would if they did not participate in the program

(Lokshin and Sajaia 2004). This may explain why many of the fishermen were not very eager with the 2014 subsidy program.

Effects of the subsidy scheme on economic performance

Table 5 presents detailed results of the estimated impacts using the comparison of profit per HP and per vessel operating with and without subsidy support. While profit is the most important characteristic to look at when comparing the efficiency of subsidized and non-subsidized vessels, we evaluated two other supplementary outcomes, cost and revenue, to examine whether improved profit is caused by input factors, output factors, or both. From the PSM method, the profit estimates of the ATT were obtained; these were compared with the ATT derived from the ESR method. The ATT estimates for cost and revenue are reported for PSM only since statistical tests to justify the use of ESR in these cases are not valid.

As seen from the PSM method in Table 5, there is strong evidence that participating in the subsidy scheme significantly increases the profit of the subsidized vessels. Through their participation, the subsidized vessels increased their profit by 527 million VND. The revenue also increased by 648 million VND for subsidized vessels. However, there is no indication of significant cost reductions after subsidization. This indicates that the improved profit of the subsidized vessels is caused mainly by enhanced revenue due to the possibility of accessing more abundant fish stocks in offshore areas and using better fishing technology, rather than cost reductions from the subsidy. This result is in line with the findings of Yagi, Senda, and Ariji (2008), although that study used a different approach and different data levels than the current study.

[Table 5]

If we use profit per HP as a proxy for return on capital (see Bell, Watson, and Ye 2016 for arguments) to measure whether a fisherman's fishing operation is efficient, the results are different from what we found when measuring profit per vessel. When using the PSM method, both the revenue per HP and the cost per HP for subsidized vessels were found to be smaller compared to those for non-subsidized vessels, or reduced after subsidization. However, the reduction in the cost was unable to cover the reduction in the revenue, so the profit per HP is actually smaller for subsidized vessels. This is a disappointing result from an efficiency perspective, and one explanation may be that the scheme has not triggered large enough investments in the individual vessels. That is, low efficiency is caused by underinvestment in vessels and gear. To check for this, we compared profit per HP for the 10% most efficient vessels, the 10% least efficient vessels, and the 10% of vessels closest to the average efficiency. The results are shown in Table 6. The table shows that the most efficient group actually has relatively low HP on average (199 HP), whereas the least efficient ones have much higher HP (507 HP). The subsidized vessels score below average efficiency and far below the most efficient vessel group. This implies that the current regulation on subsidized HP limits (minimum 400 HP) may not be optimal and should be revised. But since we have data for one year only, it is hard to assess whether or not the catch is close to the optimal point, given the new capital, and therefore to conclude with regard to too high or too low capacity. Identifying the optimal capacity for offshore fishing vessels seems to be an important task for future research.

Compared to the PSM model, the ATT estimates of profit per vessel and per HP achieved from the ESR model are slightly different− mainly larger. Normally, if "self-reinforcing effects" is indeed present, ATT from the PSM is expected to be larger than that from PSM. If fishermen with high ability self-select into the subsidy program, then part of their profit is due to their high ability rather than subsidies. PSM does not control for ability, which leads to overestimation of the effect of subsidies. One reason could be that with the low endogeneity, the ESR turns out to be an exogenous switching regression, but the structure of the model still capture accurately the effect of the subsidy. In this study, the insignificant σ_{u1} confirms the absence of unobserved heterogeneity or there is no self- reinforcing effects among the subsidized vessels. Thus, the differential effects of subsidy on the two vessel groups is possibly due to initial differences in observed factors. Most of the results are significant. The bootstrapped standard errors[vii] in both methods are small, which indicates that the results of the impact estimation are good overall. The assumptions of the two methods are also examined and their results are presented in online Appendix A.

DISCUSSION AND CONCLUSION

Many governments use subsidies—among other management tools—to assist their fishing fleets to engage in offshore and international fisheries. Research has shown that subsidies often lead to overcapacity and overfishing, resulting in the depletion of fish stocks. A few studies have, however, argued that particular subsidies can have some positive effects, but the quantification of subsidy impacts remains an important research gap. This study used a set of fisheries data from Vietnam to examine whether a capacity enhancing subsidy was a good policy for the government to use to achieve its goals. This paper also discussed the consequences of the scheme in terms of economic, social, and environmental sustainability.

The results indicate that the government has partly achieved its goal—that is, the 2014 subsidy scheme has led to increased offshore fishing, which has enhanced profitability and made the country more visible in disputed fishing areas. Using the PSM method, this paper found that the subsidized vessels have achieved a positive economic effect. This should encourage fishermen to participate in the ongoing subsidy scheme and invest in bigger and more modern vessels for further offshore fishing. Unlike most other studies, which emphasize that subsidies increase profit because they mainly reduce cost, we find that the positive economic effects primarily are caused by increased revenue due to better access to more abundant resources and more profitable fishing gears. However, if unobserved heterogeneity is taken into account (i.e., using the ESR method), the subsidized vessels are actually not more profitable than non-subsidized vessels.

This study shows that there is a selection in the recruitment to the subsidy scheme. Vessel owners with more years at sea and a certain level of equity are most likely to take part in the scheme. More years at sea probably means that they are experienced in handling both advanced fishing technology and governing the fishing more efficiently, whereas own capital is a necessary requirement to obtain the loan. Nevertheless, own capital does not imply that the fishermen fish more efficiently to enhance their profit. The results regarding the application process also provides a plausible explanation for why many fishermen do not participate in the subsidy scheme despite the increased profit that the subsidized vessels have achieved.

The scheme has not, however, solved the poor income problems of the fisheries. It has not reduced competition and pressure on resources in the inshore waters. The scheme has mainly benefited large-scale vessels and well-off vessel owners rather than small-scale, inshore fishermen. In principle, owners of small-scale vessels have not been excluded from the scheme, but they are unable to fulfill the requirements. First, they lack the capital necessary to invest in a vessel with a minimum 400 HP. Second, they have no skills and experience related to operating offshore. Third, they will probably have greater difficulty handling the application process. Thus, before joining the program, most of the subsidized vessels were already rather big in size and fishing offshore. In short, the government has not succeeded in its goal of bringing about a transition from inshore to offshore fishing, and the social sustainability of the subsidy scheme is therefore weak.

The long-term viability of the current policy can also be questioned. The fact that profit per HP, after subsidization, has decreased and been lower than that of average efficient vessels and far below that of the most efficient vessels, demonstrates that subsidized vessels are operating inefficiently. It is thus important to investigate the reasons for this inefficiency. Is it due to excessive capital used or due to inaccessible maximum catch because the vessels are still too small? We don’t know the answer yet, but most likely it indicates that overinvestment is taking place in the case of subsidized vessels in Vietnam. And if the government retains the scheme and makes it possible for more vessels to participate, the overinvestment may contribute to overcapacity and overfishing in the long term. This environmental unsustainability will accelerate the depletion of fish stocks, and in turn, also diminish the long-term profitability of the vessels—that is, their economic sustainability.

There are some advantages to employing both the ESR and PSM methods. First, the application of both PSM and ESR allowed us to check the validity of the results of the two models, one representative for parametric approach (ESR) and the other for non-parametric approach (PSM). Second, we found evidence of positive self-selection in the ESR model, suggesting that subsidized vessels actually have a comparative advantage in terms of profit over non-subsidized vessels. Unobservable factors that increase the likelihood of subsidy participation are positively correlated with unobservable factors influencing profit. While it is impossible to know precisely which factors are responsible for this negative correlation, a plausible explanation may be the individual ability (which is not based on experience) to identify the migration of species quickly. Because the ESR model can correct for the bias inherent in the conventional measurement, this triggers self-reinforcement effects on profit gained for both subsidized and non-subsidized vessels. It should be stressed that applications of ESR in fisheries studies are still scarce. There is clearly a need to further develop this method so that it can provide greater insight into the type of relationships highlighted in this paper, where statistical inference is important for policy-making decisions.

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Table 1: Summary of data distribution among the provinces

Province	Population			Sample			Sample/population (%)		
	Total	Subsidized vessel*	Non-subsidized vessel**	Total	Subsidized vessel	Non-subsidized vessel	Total	Subsidized vessel	Non-subsidized vessel
Nghe An	1069	97	972	136	46	90	12.7	47.4	9.3
Quang Ngai	1204	59	1145	60	15	45	5.0	25.4	3.9
Phu Yen	811	19	792	80	17	63	9.9	89.5	8.0
Khanh Hoa	624	26	598	89	25	64	14.3	96.2	10.7
Total	3708	201	3507	365	103	262	9.8	51.2	7.5

* by 2019

** by 2018, account for pelagic fishing vessels that have capacity of 90HP or above.

Table 2: Characteristics of subsidized and non-subsidized vessels: Summary statistics.

Mean with standard deviations in parentheses

Variable	Description (units)	Total (N=365)	Subsidized vessels (N=103)	Non-subsidized vessels (N=262)
Vessel owner's characteristics				
Education	Number of schooling years completed of the owner (years)	6.75 (2.18)	6.95 (2.60)	6.67 (1.95)
Experience	Years working as a fisherman (years)	23.52 (7.44)	23.59 (6.90)	23.49 (7.65)
Technological and activity characteristics				
HP	Engine power of the vessel (HP)	484.76 (249.66)	739.05 (162.86)	384.79 (202.5)
Gillnet	1 if fishing gear is gillnet, 0 purse seine	0.21 (0.41)	0.19 (0.40)	0.22 (0.41)
Pushnet	1 if fishing gear is pushnet, 0 purse seine	0.29 (0.45)	0.35 (0.48)	0.27 (0.44)
Longline	1 if fishing gear is longline, 0 purse seine	0.34 (0.47)	0.10 (0.30)	0.43 (0.50)
Other factors				
Application process				
Complicated	1 if complicated, 0 otherwise	0.50 (0.50)	0.13 (0.33)	0.65 (0.48)
Simple	1 if simple, 0 otherwise	0.34 (0.47)	0.59 (0.49)	0.24 (0.42)
Own capital	1 if the owner has enough capital on his own, 0 otherwise	0.75 (0.44)	0.84 (0.36)	0.71 (0.46)
Economic performance				
Revenue per vessel	Landed value of catch from fishing per vessel (mill.VND/vessel/year)	3,775.34 (1,266.06)	4,638.93 (1,207.83)	3,435.84 (1,120.42)
Cost per vessel	Cost of all the inputs per vessel (mill.VND/vessel/year)	2,762.33 (772.80)	313.00 (759.53)	2,617.79 (730.17)
Profit per vessel	Difference between the revenue and cost per vessel (mill.VND/vessel/year)	1,013.10 (678.44)	1,509.03 (649.83)	818.13 (584.53)
Revenue per HP	Landed value of catch from fishing per HP (mill.VND/HP/year)	10.03 (6.02)	6.46 (1.68)	11.43 (6.51)
Cost per HP	Cost of all the inputs per HP (mill.VND/HP/year)	7.49 (4.64)	4.41 (1.24)	8.70 (4.90)
Profit per HP	Difference between the revenue and cost per HP (mill.VND/HP/year)	2.53 (2.31)	2.05 (0.81)	2.73 (0.81)

Table 3: Propensity score estimation results

Variables	Mean
Education	0.05 (0.04)
Experience	0.03*** (0.01)
Gillnet	−0.80*** (0.26)
Longline	−1.45*** (0.28)
Pushnet	−0.28** (0.24)
Complicated application process	−1.14*** (0.19)
Simple application process	0.71*** (0.18)
Own capital	0.40* (0.22)
Constant	−1.17 (0.56)
Log Likelihood	−142.02
Pseudo R^2	0.35
LR chi2	150.32
No. of observation	365

*Note: Standard errors in parentheses; *, **, *** Significant at the 10%, 5%, and 1% levels, respectively*

Table 4: Determinants of subsidy participation and its impacts on the outcomes of subsidized and non-subsidized vessels: ESR estimates

Variable	**Profit**			**Profit per HP**		
	Selection equation	Outcome equation		Selection equation	Outcome equation	
	Subsidy adoption	Subsidized Vessels	Non-subsidized vessels	Subsidy adoption	Subsidized vessels	Non-subsidized vessels
Education	0.03	0.02	−0.04**	0.05	−0.01	−0.21**
	(0.04)	(0.02)	(0.02)	(0.04)	(0.03)	(0.09)
Experience	0.03**	0.01	−0.00	0.03**	0.01	−0.04*
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)
Longline	−1.57***	−0.82***	0.48***	−1.52***	−0.80**	2.56***
	(0.30)	(0.26)	(0.14)	(0.28)	(0.35)	(0.64)
Pushnet	−0.25	−0.52***	−0.08	−0.29	−0.64***	0.03
	(0.23)	(0.14)	(0.13)	(0.24)	(0.19)	(0.60)
Gillnet	−0.79***	−0.96***	−0.04	−0.81***	−0.75***	0.90
	(0.26)	(0.16)	(0.15)	(0.26)	(0.23)	(0.64)
Own capital	0.39*	0.19	0.20***	0.42**	0.03	0.98***
	(0.20)	(0.15)	(0.07)	(0.21)	(0.21)	(0.33)
Complicated application process	−1.02*** (0.20)			−1.00*** (0.20)		
Simple application process	0.65*** (1.66)			0.66*** (0.17)		
Constant	−1.11	1.35***	0.69***	−1.16	2.06***	3.90***
	(0.55)	(0.37)	(0.24)	(0.55)	(0.51)	(1.05)
σ_{u1}, σ_{u0}		0.10	−0.68***		−0.06	−0.61***
		(0.30)	(0.14)		(0.28)	(0.13)
Sigma		0.53***	0.57***		0.74***	2.50***
		(0.04)	(0.03)		(0.05)	(0.13)
Log likelihood		−425.81			−853.17	
Likelihood ratio test of indep. Eq. χ^2		7.67***			5.69**	
Wald test χ^2		37.76			16.5	

*Note: Standard errors in parentheses; *, **, *** Significant at the 10%, 5%, and 1% levels, respectively*

Table 5: Average treatment effects on economic performance of subsidized vessels

Outcome	PSM[viii]	ESR
	Mean	Mean
Revenue per vessel (mill.VND/vessel/year)	648.44*** (226.28)	
Cost per vessel (mill.VND/vessel/year)	121.88 (146.23)	
Profit per vessel (mill.VND/vessel/year)	526.67*** (117.78)	691.06*** (33.82)
Revenue per HP (mill.VND/HP/year)	−2.90*** (1.11)	
Cost per HP (mill.VND/HP/year)	−2.80*** (0.84)	
Profit per HP (mill.VND/HP/year)	−0.11 (0.45)	−0.68*** (0.12)

*Note: Bootstrapped standard errors in parentheses; *, **, *** Significant at the 10%, 5%, and 1% levels, respectively*

Table 6: Comparison of efficiency among vessels with average efficiency

Criteria	Profit per HP				HP			
	Mean	SD	Min	Max	Mean	SD	Min	Max
10% most efficient vessels	7.09	2.21	5.02	16.86	199.00	78.72	90	430
10% least efficient vessel	−0.23	1.65	−6.75	080	507.74	269.70	90	1150
10% average efficient vessels	2.58	0.22	2.25	2.96	518.13	240.77	90	945
Subsidized vessels	2.05	0.81	0.68	4.28	739.05	162.86	320	1100

APPENDIX A: Goodness of fit of the PSM and ESR methods

Various diagnostics were undertaken to check the goodness of fit of the PSM method.

First, the condition of common support is examined. We found that the overlap of the distribution of the propensity scores across the subsidized and non-subsidized vessel groups seems satisfactory (see Figure A.1). Furthermore, the means of the propensity score are similar within each of the four blocks across the two groups. The common support is satisfied in the region of [0.014–0.928], enforcing a loss of 8 vessels.

Second, the covariate balancing test is also performed. As shown in Table A.1, the balance for the distribution of the variables between the subsidized and non-subsidized vessels is greatly improved and few biases remains. The mean standardized bias indicating the differences in the propensity scores of the two groups are also significantly reduced. The low pseudo-R^2 and insignificant likelihood ratio test support the hypothesis that the two groups have the same distributions in variables after matching. The pseudo-R^2 decreases but is not equal to zero after matching, which means that matching reduces but does not entirely eliminate the potential bias in the estimates of impacts owing to differences in the observed covariates between the subsidized and non-subsidized vessels. These conditional tests suggest that the matching we employed works well with the data overall and the treatment effect provided by PSM makes sense.

The validity tests of the instrument variables “complicated application process” and “simple application process”, which are argued for inclusion in the ESR method, are provided in Table A.2. The Anderson and Cragg-Donald Wald tests are significant, indicating that the model does not suffer from under identification nor of weak instruments’ choice. The over-identification test also fails to reject the exclusion restriction that the instruments employed affect subsidy only through application process. In addition, we also describe details of the contextual setting of these instrument variables Last but not least, we should draw attention that ESR method relies on the joint normality of error terms between the binary and outcome equations, and therefore the results should be interpreted with caution.

Table A.1: Bias reduction (%) for distribution of the variables between subsidized and non-subsidized vessels

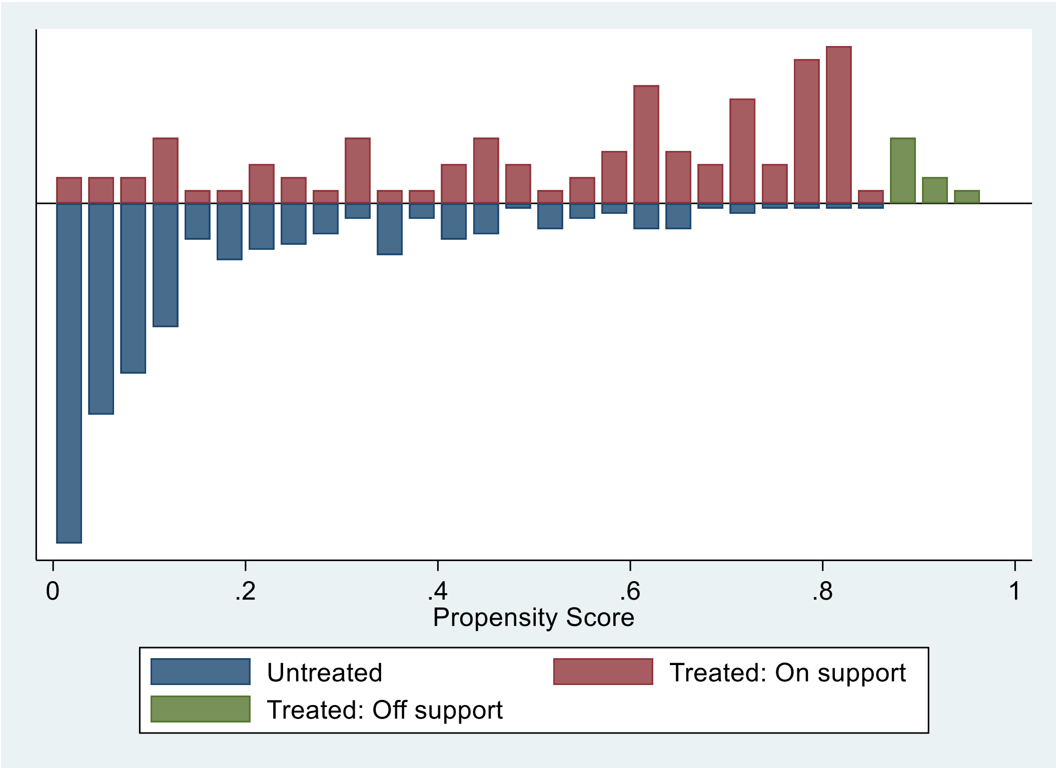
Variable	% bias Before matching	% bias After matching	% bias reduction	t-test	p value
Education	35.8	−16.9	52.9	−1.13	0.26
Experience	1.4	3.6	−153.3	0.27	0.79
Gillnet	−5.8	4.7	18.7	0.33	0.75
Pushnet	17.8	−5.1	71.6	−0.33	0.78
Longline	−81.7	−3.1	96.2	−3.1	0.79
Own capital	33.6	−3.5	89.7	−0.27	0.54
Complicated application process	−126.7	−7.8	93.9	−0.61	0.73
Simple application process	76.1	−5.4	92.9	−0.35	0.73
Pseudo R^2	0.25	0.01			
LR Chi^2	150.32	2.50			
Prob > Chi^2	0.00	0.96			
Mean standardized bias	47.40	6.3			
Rubin B (%)	167.60	22.9			
Rubin R	0.85	1.28			
Number of matched treatments		95			
Number of matched controls		262			
Number of unmatched treatments		8			
Number of unmatched controls		0			

Table A.2: Validity test of instrument variables

First stage regressions	Coefficient
Instrumented variable (participating or not participating subsidy scheme)	
F test	45.60***
SW Chi-square (underid)	93.77***
SW F (weak id)	45.60
Under-identification test (Anderson canon. corr. LM statistic)	74.60***
Weak identification (Cragg-Donald Wald F statistic)	45.60***
Weak instrument robust inference	
• Anderson Rubin Wald test F(2,355)	7.33***
• Anderson Rubin Wald test Chi-sq(2)	15.06***
• Stock wright LM S statistic	14.47***
Over-identification test of all instruments	1.05

*Note: Standard errors are in parentheses; *, **, *** Significant at the 10%, 5%, and 1% levels, respectively*

Figure A.1. The overlap and the common support region between the subsidized and non-subsidized vessel groups



ENDNOTES

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[i] Flaaten (2021)discusses a 1981 theoretical and empirical paper in the Norwegian language, published in a year where subsidies peaked, amounting to 40 % of the landed value of all Norwegian catches. Gradually, subsidies were abolished and the fisheries became one of the most profitable industry of the country.

[ii] The skills, knowledge, and ability to work to pursue different livelihood strategies.

[iii] The basic infrastructure (e.g., transport), production equipment, and means that enable people to pursue their livelihoods.

[iv] These are the economic resources (measured in terms of money), such as assets, that help people to access different livelihood options.

[v] The exact question for survey is as follows: "Did you have sufficient own capital to meet reciprocal capital required when/if you participated the subsidy program? – 1 yes, 0 no".

[vi] The exact question for survey as follows: "How would you rate the application process to receive the subsidy scheme? – 1 Complicated, 2 No clear opinion, 3 Simple"

[vii] The bootstrapped standard errors are examined for kernel matching and radius matching only. For nearest neighbour matching, we applied analytical standard errors assuming independent performance outcomes across vessels, as the bootstrap variance estimator is invalid for this matching technique (Abadie and Imbens 2006).

[viii] Results of kernel matching is reported only as they are close to those of ESR. Furthermore, it has the advantage of minimising the potential risk of bad matches that would arise from nearest neighbour matching (Caliendo and Kopeinig 2008). Results for other matching are available upon the request.