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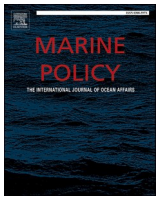

Can public credit programs improve artisanal fisher performance? The case of FONDEPES a credit program

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ABSTRACT

In this study, we show the effects of the FONDEPES credit program - a government public credit program-focused only on artisanal fishers – on profits, associativity, fish landing centers (DPA), sales destinations, and employment. We take advantage of the program's selection mechanism and the National Artisanal Maritime Census data 2012 to apply a Propensity Score Matching (PSM) methodology. The results show that receiving the credit from the program improves the profits, associativity, and sales destination. Additionally, the results are robust under different matching types, covariate balance, inverse-probability-weighted (IPW), and non-observable tests. Overall, the evidence found in this analysis suggests that the FONDEPES credit program can help artisanal fishers improve their performance. However, there are differences between the outcomes of fishermen and ship-owners, the latter being the largest. It is recommended to focus on the group of fishermen by government entities to provide training and assistance in administrative issues to leap productivity to become a ship-owner. Exploring other credit products that replace the dependence on financing from intermediaries is recommended in ship-owners' cases.

1. Introduction

In Latin America, the rural and formal financial markets have a low development, resulting in a lack of covering credit demand [1]. Also, only a small portion of the population has access to private and formal credit in the market. Due to that, the access to informal credit sources is rising and getting popular along borrowers. This logic in the market is depicted by a relaxation of private credit requirements on real guarantees and/or property titles [2,3].

The artisanal fishing sector in Latin America and the Caribbean has a value chain of more than 2.5 million workers; its production is greater than 2.5 million tons per year. Despite its importance, many communities remain marginalized with limited access to financial systems [4].

In Peru, it is relevant to mention that artisanal fisheries is defined as use of small boats or without them, with a predominance of manual labor, according to No. 25977 - General Fishing Law of Peru [5]. The artisanal fishing sector is featured by the low use of technology in equipment. However, this sector contributes to the local economy and food security of the country, since it helps to the generation of employment and the supply of fresh fish products to coastal communities [6].

It is well known that fishing is probably one of the most dangerous occupations worldwide. In that sense, access to credit provision is becoming an issue. The problem is getting worst due to the high-interest rates for lending to acquire equipment or technology in the market. It is worth mentioning that in 2012, only 17% of artisanal fishermen had access to a loan according to the National Artisanal Fisheries Census (CENPAR, for its acronym in Spanish).

The relationship between credit in one side and productivity or profits on the micro level have been discussed in economic empirical evidence in the past twenty years. One of the main results emphasis the positively and strongly effect of access to credit and productivity in enterprises [7–10]. These financial constraints prevent firms to invest in capital and technology for increase efficiency [11]. For example, Butler and Cornaggia (2011) find causal effect of access to finance on productivity using triple differences testing methodology for the farming

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industry in United States. The main result of this empirical research argues that some counties in the United States with lack of bank deposits have been powerless to increase their productivity. This result demonstrates the positive impact of access to finance on productivity [12]. Likewise, Khalily et al. (2013) study the access to credit and productivity in enterprises at micro level in Bangladesh. Applying instrumental variable, the authors found firms with access to credit have high average labor productivity [13].

However, there are another group of researches that find negative effects of access to credit and gains in productivity through relaxation of financial constraints will reduce the production efficiency of firms [14–16]. Therefore, there is a compulsion to create evidence that make visible the real impact of credit in production units, according to the context of developing economies like Peru.

In the other side, several studies have focused on examining the impacts of formal and informal credits on social outputs in the rural economy environment in developing countries. Even though there is a lack of research in the fisheries sector regarding the relationship between finance and productivity, this study will describe several empirical pieces of evidence related to these sectors, applying different quasi-experimental methodologies. Most studies point out that access to credit for fishers or producers has positive effects on relevant variables such as production, income, and sales.

For example, Duy et al. (2012) assess a public program for fisheries subsidies in Vietnam. This program was run in 2010 to help fisheries with fuel cost support, insurance subsidies, and low-rate interest loans. In addition, this study uses economic performance (EP) indicators to evaluate vessel profitability by the propensity-score matching (PSM) method. According to the authors, this subsidy program has significant positive effects on vessel profitability, increasing the probability of continued investment of fishermen [17].

Another research in the fisheries economy implemented by Pham et al. (2021) found that subsidies have had a positive effect on fishermen's profitability, revenue, and profits. Furthermore, the authors applied score matching and endogenous switching regression methods to analyze the impact of Vietnam's subsidy scheme for fishermen with favorable loans to build or modernize their vessels [18].

Furthermore, there is research in the rural aquaculture sector, which has several similarities to the artisanal fisheries sector. In detail, Rand and Tarp (2009) evaluated a public program in Bangladesh to support local aquacultures through credit, infrastructure, and technical assistance. The authors applied a Differences in Differences (Diff-in-Diff) methodology with a sample of 110 observations. Thus, the study concludes an increase in the fisher production value and producer profit [19].

On the other hand, there is solid evidence of a series of research related to identifying the effects of credit on productivity in the agriculture sector. For example, Jimi et al. (2019) analyze the relationship between access to credit and the productivity of small rice producers in Bangladesh. Applying a randomized methodology, this study used data from 4311 producers from 2012 to 2014. The authors focus on changes in the stochastic frontier of production and technical efficiency to conclude those producers who accessed credit improved their productivity by 14% compared with the group of producers that did not receive credit [20].

Likewise, a random experiment by Crepon et al. (2015) in Morocco about microcredits provision shows that beneficiary households invest more than other sectors [21]. Additionally, their income has increased due to the investment. In addition, there are solid evidence of a positive relationship the access to credit and some other relevant indicators, such as productivity, sales, and income in several developing economies [22–25].

Even though the studies revised above explain the relevance of credit in the rural economy. However, there is no evidence of these effects on Latin American economies such as Peru, Mexico, or Chile, where the artisanal fisheries sector represents an opportunity to increase economic development for people.

This study aims to measure the impact of credit provision through a public credit program provided by the National Fisheries Development Fund (FONDEPES)[1]. The analysis focuses on artisanal fishing agents -fishermen and ship-owners-. The methodology employed shows results on profits, sales destinations, crew, fish landing center (DPA), and associativity variables. Additionally, four tests have been employed to prove the robustness results.

The sample has been built by combining the FONDEPES administrative database and the CENPAR. On the one hand, the treatment group comprises 318 fishing agents who have received credits from the program from 2010 to 2011. On the one hand, the control group, who did not receive the credits, is registered in CENPAR 2012, reaching 38,723 observations. Finally, a Propensity Score Matching (PSM) methodology has been employed to measure the impacts of the FONDEPES credit program.

In order to validate the result's consistency, many robustness tests have been applied to assess the existence of causality. In addition, covariate tests were used to show the correction in bias after applying the PSM.

The results have shown a positive and significant impact on the beneficiaries across all the observed outcome variables. The fishing agents with access to the FONDEPES credit increased their profits by Nuevo Sol Peruano (PEN)[2] 245.83 per month compared to the control group. Also, positive and significant effects have been found for sales destination, associativity, and fish landing center (DPA) variables.

This study contributes to the literature being the first study for a Latin American country, Peru, that measures the effect of a credit public program focused on artisanal fisher using causal inference to find the effects in the outcomes mentioned above. Additionally, we employed for first time the CENPAR a national census for artisanal fishers permitting us to have more external validity from our results. Finally, this study contributes to the literature related with the effects of credit programs showing, once more time, that these kinds of strategies are good to try to closer some gaps and contribute with the development of the beneficiaries.

1.1. The program

In 1992, FONDEPES was created by the Peruvian government as a decentralized and autonomous public institution by merging various funds for the financing of fishing infrastructure, which fosters the competitiveness of fishing activity in the country through the development of fishing infrastructure, financial support, and training for artisanal fishermen. The General Direction of Projects and Financial Management for the Development of Artisanal Fishing and Aquaculture (DIGEPROFIN) provides the credit program. It has operated, under demand, since the FONDEPES creation. In 2012, according to the fishing census there were a total of 39,788 fishermen and 9969 ship-owners. FONDEPES loan data has been systematized since 2010 into an Integral Credit Management System (SIAC). More than 2770 FONDEPES credit requests have been made from 2010 to 2018. From this group, only 2598 credits were approved.

The selection of the beneficiaries' program takes place in three stages. The diffusion program gives the first stage. The zonal financial representative prepares a weekly schedule to visit different fishing work areas. The zonal financial representative is in charge of the diffusion, evaluation, and placement of credits at the DPA, Regional offices of the Production sector (DIREPRO), and FONDEPES main office, among other designated. Each region is assigned an office where the zonal representative attends the credit requests of the fishing agents. The diffusion

[1] By its acronym in Spanish

[2] PEN is the Peruvian currency. Approximately, one dollar is equal to 2.64 PEN in 2012.

is also carried out through fairs organized by others Public Institutions. Nevertheless, the participants of these events drop out of the opportunity to be part of the control group due to is not possible to identify in a dataset the real participants.

The second stage is the preliminary evaluation. The fishing agents interested during a diffusion event or addressed directly to the zonal financial representative were registered in a notebook for a first evaluation. In this assessment, the following criteria are verified: (i) have a national ID; (ii) private loan historical credit risk (iii) FONDEPES loan historical credit risk; (iv) no more than 65 years old; (v) to be formal to fishing; (vi) at least one year of labor experience in fishing; and (vii) a valid ownership registration. In the context of artisanal fishing, the definition of a ship includes all those with a capacity of up to 32 m3 for the present document.

According to the third stage, the zonal representative prepares the credit file containing the candidates' technical and economic reports for preliminary evaluation. The candidates must propose the equipment or service needed through a competitive market price supported by a pre-invoice. The FONDEPES evaluates whether the supplier is formal or not. The zonal representative collects all the applicants' documentation, then scans it and sends it to the main office in Lima for the beginning of the evaluation stage. The process takes two or three weeks from the preliminary evaluation to the approval or rejection. FONDEPES does not deliver cash directly to the fishers.

The approved credit could be assigned to fishermen or ship-owners according to their needs. In that sense, it was observed that ship-owners are more likely to request isothermal engines and thermal insulation holds than fishermen because ship-owners are operating in the market as business owners. The approved credit has an interest rate of 3% for a loan amount up to 04 UIT (PEN 16,600) and 7% for a loan exceeding 04 UIT (PEN 16,600) to 40 UIT (PEN 166,000).

The Fig. A1 contains a proposal of the theory of change with the objective of identify immediate, intermediate, and final effects of the credit provision to artisanal fisheries, it is developed according to (i) the literature review; (ii) the systematization of the expected results and (iii) knowledge about the program.

The structure of the document is as follows: Section II presents the Materials and Methods describing the data employed and the evaluation strategy. Section III presents the results and the robustness employed in the research. Section IV shows the conclusions and policy recommendations.

2. Materials and methods

2.1. Data

The data was built using the SIAC and CENPAR. The former is a FONDEPES administrative database that systematizes loans approved from 2010 onwards. This sample contains a wide range of financial variables. This information was complemented with the CENPAR database, which contains socioeconomic information about fishermen, ship-owners, ships, fish landing places, and shipyards.

According to the 2010–2018 period, 2020 fishing agents benefited from FONDEPES credits-SIAC-. The SIAC only provides a wide range of variables with financial information. For complementary information, the CENPAR has been employed, specifically for the socioeconomic database, reaching 1428 fishing agents (71%) compared to the beneficiaries (2020). Nevertheless, it is important to mention that our analysis is based on the year 2012 due to the CENPAR; our principal dataset was just recollected that year.

Table A1, from the Appendix, shows the descriptive statistics. Then, the statistics analysis highlights the differences between the beneficiaries. It can be observed that the ship-owners, in comparison with fishermen, are older (47 years old); 43% (4254) of them have completed high school or more, 53% (5162) are separated, and 17% (1647) of them are women.

Regarding the economic activity, 91% (9036) of the ship-owners work in artisanal fishing as the main activity, and 22% (2211) of them carry out a secondary activity such as commerce (7%; 702) and construction (3%; 282), and 46% (4561) of them have up to 5 years of labor experience in the sector. By contrast, 99% (39,691) of the fishermen are dedicated to artisanal fishing as their main activity, and 32% (12,822) have a secondary activity, such as construction (10%; 4075) or agriculture (8%; 3105).

The estimated monthly profit of ship-owners is PEN 2102, and 84% (7943) have at least one ship formally registered. On the other hand, the fishermen have a low monthly average profit (PEN 721.2), which highlights informality (52%; 20,642), understood as the condition of not having a valid authorization. Furthermore, on average, a ship-owner employs four fishermen as a crew and has more than one ship. The fish hold capacity per owner is, on average, 3.58 m3, and 33% (2994) of them have at least one ship with an insulated fish hold preservation type, 19% (1785) bulk cargo, and 16% (1479) isothermal.

2.2. Variable selection

The present study selects different explanatory variables that represent a fishermen or ship-owner pretreatment characteristics following the theory of change and previous studies that has analyzed the effect of credit on fishermen [17,19,22–26].

In this sense, we focus are around the experience in fishing activities, age, the level of education, the quality of services that has their household (water, electricity), gender, the formality of the business, access to credit for the slaughter, access to private credit, the realization of secondary activities and the distance to fish. These variables are expected to influence our five outcomes (profit, associativity, DPA, wholesale and crew). Table 1 reveals and define all the covariates and outcomes used in the present research.

Table 1
Definition of variables.

Variable	Definition
Experience fishing	Experience in fishing activities (years)
Age: 45 years or more	Variable which takes the value of 1 if beneficiaries has more than 45 years old; otherwise, 0
Secondary education	Variable which takes the value of 1 if beneficiaries have a secondary level or more; otherwise, 0
Water	Variable which takes the value of 1 if beneficiaries have water public supply in their house; otherwise, 0
Electricity	Variable which takes the value of 1 if beneficiaries have access to electricity in their house; otherwise, 0
Secondary activities	Variable which takes the value of 1 if beneficiaries are carried out secondary activities; otherwise, 0
Gender	Variable which takes the value of 1 if beneficiaries are a man; otherwise, 0
Formal	Variable which takes the value of 1 if beneficiaries have a valid accreditation of fishing activity or at least one ship with a valid registration; otherwise, 0
Slaughter	Variable which takes the value of 1 if beneficiaries have access to other credit for his slaughter; otherwise, 0
Private credit	Variable which takes the value of 1 if beneficiaries have access to other credit different than FONDEPES (Bank or "Caja Municipal"; otherwise, 0
Type of agent	Variable which takes the value of 1 if beneficiary is a fishermen and 0 if is a ship-owner
Miles	Variable which takes the value 1 if beneficiaries do their activity in more than 10 miles; otherwise, 0
Profit	Estimated profits of the fishing agent
Associativity	Variable which takes the value of 1 if beneficiaries behind to social organization of artisanal fishermen; otherwise, 0
DPA	Variable which takes the values of 1 if beneficiaries landing in DPA; otherwise, 0
Wholesaler	Variable which takes the values of 1 if the catches are selling to wholesaler; otherwise, 0
Crew	Number of people working for a ship-owner

Source: CENPAR, SIAC. Elaboration: Authors.

2.3. Methodology

The treatment group comprises fishermen and artisanal ship-owners who received credits from the FONDEPES program from 2010 to 2011 (348). The comparison group comprises fishermen and artisanal ship-owners who have not received the intervention and were selected from the CENPAR framework in 2012 (38,723). In this way, the comparison between both groups allows us to calculate the attributable impact of the FONDEPES credit program (Table 2).

The effect of receiving a FONDEPES credit has been evaluated over two types of beneficiaries: (i) artisanal fishermen and (ii) ship-owners. In both cases, the outcome variables are defined by profits, associativity, access to a fish landing center (DPA), and destination sales (wholesale). In addition, a proxy variable has been designed to measure labor employment variables only for ship-owners called "crew".

2.3.1. Empirical strategy

The program works under demand. The probability of receiving credit is not random among the population of fishermen or ship-owners. It means that the eligibility of the beneficiaries is based on certain criteria. In that case, we face a selection problem when the set of observable covariates and the outcome variables differ among the treatment group ($T = 1$) and control group ($T = 0$) [27].

The triggers biased estimators and do not allow attributing the difference in outcomes variables to treatment exposure; therefore, this situation does not allow the opportunity to establish a causal relationship [28]. The main challenge of impact evaluation designs is the construction of counterfactuals [29]. In theory, the effect of the intervention -represented by the term α-, is defined as the difference between the individuals with intervention and its respective counterfactual, as follows:

$$\alpha = E(Y_i(1)|T_i = 1) - E(Y_i(0)|T_i = 0) \quad (1)$$

Where, Y_i denotes the outcomes variables of the individual *i*. For participants $T_i = 1$ and the value of Y_i under treatment is represented as $Y_i(1)$. For nonparticipants $T_i = 0$, and Y_i can be represented as $Y_i(0)$.

The problem is that the treated and control groups may not be the same prior to the intervention. Thus, the expected difference between those groups may not be due entirely to program intervention. The Propensity Score Matching (PSM) methodology has faced this problem.

According to the data availability, the outcome variables have been obtained from CENPAR (2012) through a cross-section layout. According to the assumption of PSM methodology, it allows for removing biases based on observable variables using a propensity score defined by $p(X_i)$ [30]. The validity of this methodology depends on two conditions: conditional independence and common support.

The assumption of conditional independence for treatment T does not affect covariates; given this, the outcomes X are independent of treatment allocation [27]:

$$\left(Y_i^T, Y_i^C\right) \perp T_i|X_i \quad (2)$$

In this way, Y_i^T represents the outcomes that belong to the treatment group, while Y_i^C represents the outcomes of the comparison group. This implies that being part of the intervention depends only on observable characteristics. This assumption is known as unconfoundedness [30].

Table 2
Treatment and control groups definition.

Condition	Definition	Sample size
Treatment	Fishermen or ship-owner received a FONDEPES credit between 2010 and 2011, according to SIAC	348
Control	Fishermen or ship-owner appear in CENPAR (2012) and never receive credit from the FONDEPES program.	38 723

Source: CENPAR, SIAC. Elaboration: Authors.

The second assumption about common support ensures that the treatment group observations have similar scores to the control group along with the distribution of propensity scores [31]:

$0 < P(T_i = 1|X_i) < 1$

The logit probability model for the FONDEPES program is given by:

$$\Pr(T_i = 1|\boldsymbol{X}) \equiv p(X_i) = F\left(\boldsymbol{X}_i'\gamma\right), such \quad that \quad F(z) \equiv \exp(z)/[1 + \exp(z)] \quad (3)$$

The average treatment on treated (ATT) is given by:

$$\widehat{ATT} = \frac{1}{N_1}\sum_{i|T=1}\left[Y_i - \widehat{Y}_i^0\right], \ where \ \widehat{Y}_i^0(p_i) = \left\{j : |p_i - p_j| = \min_{j\in\{D=0\}}\left\{|p_i - p_j|\right\}\right\} \quad (4)$$

Where Y_j is the outcome variable, N_1 is the number of fishermen or ship-owners who have received a credit from FONDEPES, N_0 is the number of controls, $p(X_i)$ is the value of predicted probability for ship-owners or fishermen i [32]. It is worth to mention that the nearest-neighbor, -one to one estimator-, has been used as a matching method.

2.4. Robustness check

In order to examine the robustness results presented and their causal effect, four tests have been employed in this analysis, such as (i) sensitivity to unobservables; (ii) matching method sensitivity and IPW approach; (iii) covariant balance, and (iv) falsification test [33]. Rosembaum's (2002) method has been done to test how robust is the ATT estimation on the existence of the unobservable [34]. In addition, the second test seeks to prove how robust is the ATT estimation concerning the different matchings.

We complement our regressions using the IPW methodology. This methodology reweights the data from the treatment and control groups to try to ensure that they have a similar distribution of observable characteristics. It will provide a robustness result from out estimations. In addition, a covariate balance has been done according to Smith and Todd (2005) [35]. Finally, to validate the ATT estimation, a falsification test has been applied [36].

3. Results and discussions

3.1. Covariate balance test

The balance of covariates has a fundamental role in proving the methodology's robustness and correcting pre-existing differences along the treatment and comparison groups [29,30,37]. In this analysis, the media test has been used two times, previous to the PSM and after that. At the first moment, 92% of covariates have significant differences between both groups at a 10% significance level. Finally, after the matching, all the covariates are not showing significant differences at the same level as we can see in the Table A2. Thus, we are ensuring the correct specification for our PSM.

According to the common support shown below, the Kernel distribution graph depicts two moments. Before employing the PSM methodology, the results show no distribution overlap. This situation could be explained by the difference in observable variables for both groups (treatment and control). After applying the PSM, the distribution exhibits an overlap. In this line, the assumption of the existence of a common support for the PSM methodology is fulfilled after the implementation of the matching. In the Fig. A2, we can see all the common support for the rest of the outcomes analyzed in the present study. (Fig. 1).

According to Fig. 2, the selection bias in covariates employed under a PSM shows the nearest zero value (bias) related to the matched observations. In contrast, the results of unmatched observations show a high bias. Thus, our empirical strategy shows the bias correction after the

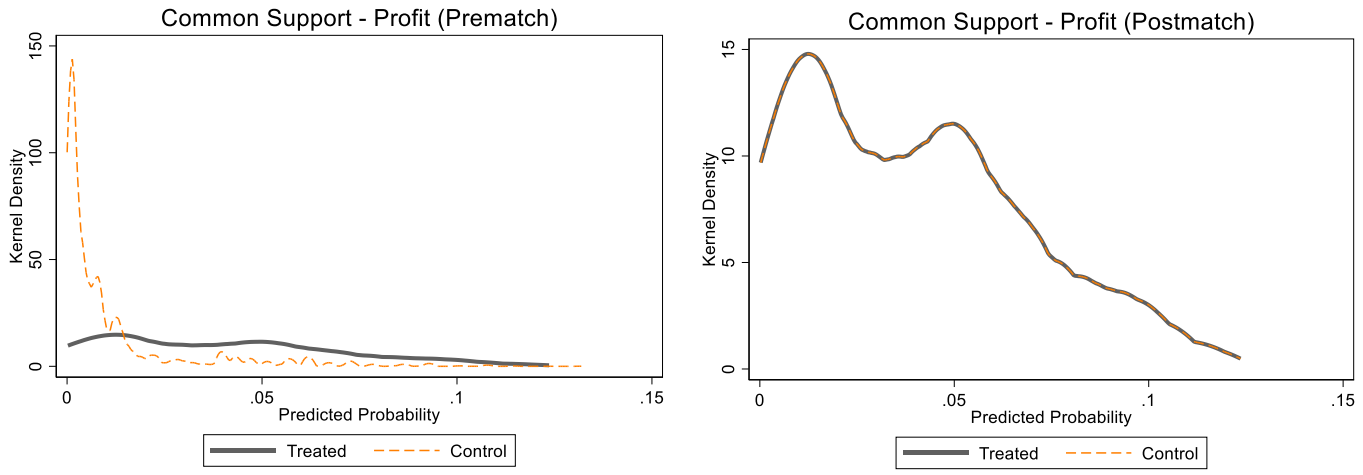

Fig. 1. Common support from Profits.

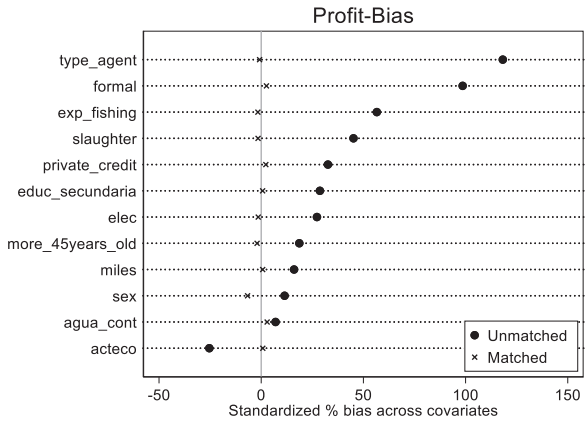

Fig. 2. Profit Bias before and after matching.

implementation of the matching procedure. In the Fig. A3, it is possible to observe the rest of bias correction for all the outcomes. Thus, we can ensure that the development of the PSM correct the bias based on observable characteristics.

3.2. Main results

The ATT has been estimated using the Nearest-neighbor methodology. Table 3 shows that those who had access to FONDEPES credit increased their profits by PEN 245.83 per month compared to the control group. This result reveals that access to FONDEPES credit exhibits a significant improvement in terms of fishermen's and ship-owner profits.

Table 3
Main Results-PSM.

Outcome	Agent type	ATT	SE	N
Profit	fishermen + ship-owner	245.83 **	146.73	600 (300 T; 300 C)
Associativity	fishermen + ship-owner	0.15 * **	0.04	602 (301 T; 301 C)
DPA	fishermen + ship-owner	0.09 * **	0.04	572 (286 T; 286 C)
Wholesaler	fishermen + ship-owner	0.06 * *	0.03	602 (301 T; 301 C)
Crew	Ship-owner	0.53 * *	0.28	362 (181 T; 181 C)

Notes. Distribution of sample size in parentheses. *** significant at 10 % level, ** significant at 5 % level, *** significant at 1 % level

It could be explained by the fact that machinery and equipment[3] are given by the program. Therefore, it causes an immediate impact on fishermen's daily work. However, there needs to be more information available to explore the scope of this impact, that is, whether the increase in income is sustained over time or in the long term. A new artisanal fishing census at the national level is required to delve into this matter. Likewise, the improvement in income due to access to financing is limited by the level of education, gender differences in the provision of assets, and infrastructure of the productive chain, among others [38,39].

Receiving credit from the FONDEPES program from 2010 to 2011 increases the probability of landing fishing resources at a DPA by 0.09 p. p. [17]. In general, the DPA has an infrastructure and equipment that helps maintain the cold chain, thus ensuring higher product quality and price. However, in Peru, it is observed that there are still vessels whose access to the DPA is a dirt road, which negatively affects the value of the product [39]. Another effect is observed over the sales destination. In that case, receiving the credit from the FONDEPES program increases the probability of destining the sales to wholesalers or intermediaries by 0.06 p.p. In the short term, the fact that the sales destination is the intermediary means that the income is assured since they also finance the fishing trips through the necessary capital for gasoline or the crew's salaries in exchange for obtaining the sale of the catch at a set price. On the other hand, in the long term, this may mean a limitation in the search for increased investment and productivity [40].

In the case of the association variable, having access to a FONDEPES credit program has a positive effect over the association variable (0.15 p. p.). The associativity between the artisanal fishermen is important as it means support and a better organization with common objectives; on the other hand, most of the DPA are administered by the Social Organization of Artisanal Fishermen (OSPA) composed by fishermen and not by administrators, which can mean a limitation in the management capacity since they could respond to criteria of directives and not of efficiency. The search for shared management between OSPA, the public, and the private sector can be considered an alternative in management in search of a productive management model [39]. From the ship owner's perspective, a grant of credit from the program exhibits positive effects, resulting in an increase in the probability of hiring artisanal fishermen (crew). The results show an increase in employment measured as the number of fishermen on the ship's crew; however, artisanal fishing is a broad market in the production chain. In this sense,

[3] For example, fishermen could access equipment such as fishing nets, increasing their daily work productivity. As well as, the ship-owner increases his profits by accessing new machinery, for example, shipment motors or insulated fish holds.

it generates direct and indirect, formal and informal jobs throughout the process. There needs to be more evidence about the impact on these other types of employment. Finally, the PSM overall results show 5 % significance along the five outcomes.

In summary, these results are explained partially by the increase in catching. The agents optimize the fish landing place to have access to a DPA, which offers multi-services and opportunities for commercialization. They can find dockers, artisanal sellers, and special infrastructure at the fish landing place to ensure the resource cold chain. The effect on the sales destination to wholesalers or intermediaries may be depicted by an initial sales contract dealt with before the fishing trip, and the wholesaler or intermediary usually finances it.

3.3. Heteregeneous impacts by beneficiaries

On the one hand, the fishermen beneficiaries who obtained a FONDEPES credit increment their monthly profit in PEN 164.4. However, the results show no significant effects over the same variable for ship owners, even if the sign of the effect has not changed. The ship-owner has more capital than the fisherman. By having a boat with an insulating mechanism, he can spend more time at sea, increase the catch and maintain the quality of the product. An opportunity for improvement is to become a ship-owner; however, increasing capital, assets, and productivity is necessary. An analysis of this particular issue would indicate whether the challenge consists of a structural problem or one of the financing amounts. A new census can help to follow up on the population of fishermen, their financial behavior, and whether any of them became ship-owners.

Related to the association variable (OSPA), the heterogeneous impacts of artisanal fishermen show a positive effect by 0.16 p.p. over the comparison group. On the other hand, the ship-owner who receives a credit from the program has a positive effect of belonging to an OSPA by 0.12 p.p.

In addition, the results show impacts on the fish landing place (DPA) and the sale destination. It means that receiving the credit from the program increases the probability of landing at the DPA and selling to a wholesaler or intermediaries. However, those results are only significant for fishermen. The heterogeneous effects by beneficiary are shown in Table 4. In general, a greater magnitude is observed in the ATT for the variables of associativity, landing place, and sales destination for the fishermen. It is to be expected given that the ship-owners have working capital, which means their access to external financing occurred previously. As mentioned before, one option to make the leap in productivity for the fisherman is to become a ship-owner. On the other hand, ship-owners are also restricted when committing their sales to intermediaries. A solution would be another marketing model for their capture, which requires the entire process chain (roads, transport, refrigeration). The search for alliances with international cooperation and the private sector can mean a way out [39].

Table 4
Heterogenous effect by type of agent.

Outcome:	Type of agent	ATT	SE	N
Profit	fishermen	164.41 **	81.07	222 (111 T; 111 C)
	ship-owner	182.18	205.53	376 (188 T; 188 C)
Associativity	fishermen	0.16 ***	0.06	224 (112 T; 112 C)
	ship-owner	0.12 ***	0.05	376 (188 T; 188 C)
DPA	fishermen	0.19 ***	0.07	210 (105 T; 105 C)
	ship-owner	0.04	0.05	362 (181 T; 181 C)
Wholesaler	fishermen	0.14 ***	0.06	224 (112 T; 112 C)
	ship-owner	0.03	0.04	376 (188 T; 188 C)

Notes. Distribution of sample size in parentheses. *** significant at 10 % level, * * significant at 5 % level, *** significant at 1 % level

3.4. Robustness check

3.4.1. Covariance balance: Smith and Todd test

The literature mentioned a road to test the robustness of the results when a study employs a PSM methodology. In this sense, the Smith and Todd test has been used to ensure the robustness of the covariates balance analysis.

Briefly, the test seeks to validate the assumption of being part of the treatment group based on observable characteristics as suggested by the PSM methodology with the development of a polynomial test.

Table A3 depicts the observable variables used to estimate the program's impact. Likewise, each outcome's test results are presented to ensure the causal effect.

Almost all the variables used for the matching are not statistically different for the treatment and comparison groups. These variables are the fishing experience, age (more than 45 years old), education level (high school or more), access to electricity, public water supply, secondary economic activities, gender, formality, finance fishing trip, fishing distance (more than 10 miles) and access to banking loan (private system). It is worth remarking that almost all variables aforementioned are similar for both groups.

In conclusion, the presented results are robust for four outcomes among five according to the Smith and Todd polynomial variant test. In other words, the application of this test shows that 100% of the covariates are not presenting significant differences between both groups. Whereas for the DPA variable, 92% of the covariates are similar between both groups.

3.4.2. Sensitivity to matching method and IPW approach

The methodologies used in this document are frequently employed in the literature related to impact evaluations. Many algorithms are available to find the best comparison group related to the PSM technique. Therefore, the outcomes are re-estimated using different matching forms, such as Nearest Neighbors (3 and 5) and the Caliper matching. In addition, the Ordinary Minimum Squares (OLS) have been used to give a robustness check to the results.

This type of matching implies a trade-off between variance and bias. It means that having a high number of nearest neighbors causes a low variance (shrinking his value) but, simultaneously, a high bias [41].

After applying the nearest neighbor matching (to 3), results show significant and positive effects on profits, associativity, fish landing place (DPA), and sale destination to wholesalers or intermediaries, whereas the effects of the crew variable show no significance.

However, applying the nearest neighbor matching (to 5), the results of all variables show a positive and significant effect. Likewise, these results remain significant and positive according to the radius Caliper methodology (0.001) applied. Also, the results re-check through an OLS shows positive and significant effects, in the same way, over profits, associativity, and sale destination. (Table 5).

3.4.3. Falsification test

The falsification test follows the Lee and Lemieux methodology, which seeks to validate a causal relation between the beneficiaries from FONDEPES credit and the five outcomes assessed. This causality should guarantee spurious-free association outcomes [36].

The variables tested according to that methodology, empirical and theoretical, should not have shown significant impacts.

It is worth mentioning that two pseudo-outcomes are being chosen to test the different beneficiaries. In this regard, the results in Table 6 show no treatment effects on pseudo-outcomes; therefore, the impacts found in the treatment group are correctly identified, avoiding spurious correlations.

3.4.4. Sensitivity to unobservable variables

The PSM matching methodology is based on the assumption of conditional independence along with common support. In this case, this

Table 5
Sensitivity to matching algorithms, OLS and IPW approaches.

Outcome:	3 nearest neighbors		5 nearest neighbors		Radius Caliper		OLS		IPW	
	ATT	SE	ATT	SE	ATT	SE	ATT	SE	ATT	SE
Profit	285.93 *	(185.80)	311.39 **	(155.23)	482.50 **	(250.20)	238.69 ***	(49.74)	170.57 *	(90.30)
Associativity	0.14 ***	(0.04)	0.16 ***	(0.04)	0.12 **	(0.07)	0.17 ***	(0.03)	0.17 ***	(0.03)
DPA	0.13 ***	(0.05)	0.11 ***	(0.04)	0.22 ***	(0.07)	0.02	(0.03)	0.01	(0.03)
Wholesaler	0.10 ***	(0.04)	0.08 **	(0.03)	0.12 **	(0.06)	0.05 **	(0.03)	0.02 **	(0.02)
Crew	0.44	(0.40)	0.47 *	(0.33)	0.83 *	(0.62)	0.05	(0.24)	0.00	(0.21)

Notes. Standard errors are in parentheses. * ** significant at 10 % level, * * significant at 5 % level, * ** significant at 1 % level

Table 6
Falsification test.

	Type of agent		
Variable	fishermen +ship-owner	fishermen	Ship-owner
Gender	0.00	0.01	–0.01
	(0.01)	(0.01)	(0.01)
Disability	0.01	–0.02	0.03
	(0.03)	(0.04)	(0.04)

Notes. Standard errors are in parentheses. *** significant at 10 % level, ** significant at 5 % level, *** significant at 1 % level

test seeks to offer evidence about the existence of unobservable characteristics which could disrupt the treatment effect [34].

The probability of receiving a FONDEPES credit is given by $\Gamma = 1$; when $\Gamma > 1$ the probability of receiving a FONDEPES credit in the treated group is higher than the control group in Γ times. It could be explained by unobservable characteristics influencing the probability of being a beneficiary [33].

If Γ is given by $1 < \Gamma < 2.5$ the results are not showing sensitivity due to the existence of moderate hidden biases. While, when $\Gamma > 2.5$, the results are not sensitive to the presence of strong hidden biases.

To evaluate the robustness of significant impacts obtained from the PSM, a Rosenbaum test (Table A4) has been conducted. The effects of having access to FONDEPES credit for two out of the five outcomes (profit and crew) show significance up to the critical value of $\Gamma = 5$. This implies that if the probability of receiving a credit from the program has an unobserved variable, that quintuple of this probability, the results would have shown the same effects as before.

The FONDEPES credit effects related to profits and crew variables remain significant, facing the presence of unobservable variables. Variables such as associativity, fish landing center (DPA), and sales destination are affected by moderate hidden biases.

4. Conclusions

The present study seeks to generate evidence for the artisanal fishing sector by employing impact evaluation methodology. The main objective of this paper is to measure the impact of receiving a FONDEPES credit program in Peru. For that, five outcomes were analyzed: profits, crew, fish landing centers (DPA), associativity, and sales destination. The study measures the heterogeneous impacts of beneficiaries related to four outcome variables.

The probability of receiving the credit from the FONDEPES program is not random; thus, a problem of selection bias is generated. The PSM method has been employed to figure out the biases based on observable characteristics within the sample. In that sense, five robustness tests have been used to prove the attribution of program causality effects.

The results show that the effect of receiving a FONDEPES credit increases significantly, such as the monthly profits increased to PEN 245.83. Likewise, those who obtained the program credit are likelier to belong to an association (0.15 p.p.). According to the fish landing place, the probability of landing at a DPA has been increasing by 0.09 p.p. Moreover, the probability of selling to a wholesaler or intermediary increases by 0.06 p.p.

The evaluation shows that the FONDEPES credit program positively impacts employment. In the ship-owners case, being a FONDEPES credit beneficiary has a positive and significant effect on employment by a factor of 0.53 on the number of employees on board (crew).

In addition, the heterogeneous effects shows that the program has the biggest impact in fishermen than in ship-owner. In this sense, the fishermen increased their profits in 164.41 PEN; however, the effect on ship-owner is not significant. In the same line, we found effects in DPA and wholesaler where the coefficients are 0.19 pp. and 0.14 pp., respectively but just for fishermen. For both type of agents, we found positive and significant effect on associativity.

The robustness test shows that the results are attributable to the program. The covariate tests (means test and the Smith and Todd test) show no significant differences in both groups according to the observable characteristics. According to the results of the falsification test, only two outcomes (gender and disability) are free of spurious correlations. However, the results of associativity, access to a DPA, and sale destination show the existence of some moderate hidden bias. Using different type of matching the results maintenance showing robustness. Nevertheless, using the IPW approach we found effects in three outcomes: profit, associativity, and wholesaler.

According to the previously estimated results, there are some policy recommendations that could enhance social welfare in the local economy of main Peruvian regions where small-scale fisheries are relevant. For instance, improving the targeting and quantity of credit could enhance program efficiency. Additionally, it is recommended to complement the program with other services such as financial education and risk management in the fisheries sector, as this could amplify the positive effects on fishermen and ship-owners. There are other policy measures that should be led by the Ministry of Production, focusing on changing the institutional framework of the sector to prevent negative externalities that may undermine the expected program benefits. Lastly, we strongly recommend conducting a new census with the aim of assessing long-term effects and capturing a different cohort of artisanal fisheries. (Table 7).

The implementation of public policies for artisanal fisheries in Peru lacks solid evidence of their potential effects on productive variables. This research, therefore, stands as a pioneer in highlighting the positive effects of programs aimed at improving productive development in small-scale fisheries. Over the past twenty years, a significant gap has persisted in addressing the negative impacts of politically driven public policies. Consequently, there exists a tremendous potential for developing robust public policies in the fisheries sector to foster economic growth.

FONDEPES is a unique public institution that provides productive support to small-scale fisheries across various regions in Peru. Enhancing their services has the potential to create a significant positive impact in numerous communities. The staff at FONDEPES actively participate in local economic development initiatives. They maintain close relationships with fishermen and local stakeholders, and their training and funding activities have equipped them with practical knowledge derived from day-to-day operations. This knowledge can be

Table 7
Policy Recommendations.

Actions or Policy	Responsible
Targeting of beneficiaries is crucial for effectiveness of the public budget.	FONDEPES
The program needs to give a differential quantity of money depending on the characteristics of beneficiaries such as ship-owner or fisherman.	FONDEPES
Increasing facilities to make easier access to credit for fishermen through reducing asymmetry of information. This could include finance education and other topics like set business networks or risk management in the fisheries sector.	Ministry of Production
Complement the program with specific training in topics as financial culture helping fishermen and ship-owners in how to manage their finances.	FONDEPES
The credit could fund another fixed cost for fishermen like license to work and other permissions.	FONDEPES
Facilities to access to private credit after participating in FONDEPES program, less restrictive credit for fisheries activities in alliance with private banks.	Ministry of Production
Work with private institutions to increase credit supply in fisheries activities.	Ministry of Production
Communicate to stakeholders in the fisheries sector and financial sector results of this credit program, and how this could increase the performance of the value chain.	Ministry of Production
Improving financial products for artisanal fisheries, offer more flexible financial instruments according to their stage of the small enterprises.	FONDEPES
Developing a new census to measure long term effects and different cohorts.	INEI

Notes. National Institute of Statistics and Informatics – INEI, by its acronym in Spanish.

instrumental in understanding the dynamics of the sector and formulating improved public policies.

In summary, the artisanal fisheries sector in Peru plays a crucial role in enhancing food safety, income, and employment. This research has highlighted the importance of government support in attaining these social outcomes within the rural economy for artisanal producers and policymakers. Such empirical evidence strengthens the foundation for developing improved public policies that ensure sustainability and promote the formalization and specialization of the sector over time.

Author contributions

L.A. and F.C formulated the idea. F.C. developed the methodology and estimation strategy. G.A. designed the theory of change and the literature review. R.T. worked in the program description, data cleaner and descriptive statistics. L.A. and F.C. supervised the research and revised the manuscript. All the authors wrote the manuscript and performed the analysis of the results. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

Data Availability

Data will be made available on request.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi: 10.1016/j.marpol.2023.105792.

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