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Credit Access and Productivity in the Marine Economy: An Empirical Analysis

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Abstract

The credit market plays a crucial role in providing households with the financial resources needed to invest in fisheries tools and equipment, enhancing their productivity. In contrast, imperfection within the credit market reduces the availability of financial access for those within the marine economy, which negatively impacts fisheries production. This paper examines the relationship between household access to credit and marine productivity as measured by fishery productivity. Using data from 72 countries and territories and employing the fixed effect model, the findings suggest that greater access to credit increases the productivity of fisheries. This study also analyses the relationship between credit access and marine productivity by further dividing countries into landlocked and non-landlocked countries and developed and developing countries. The findings show that landlocked, non-landlocked, and developing countries have a positive correlation between household credit and marine productivity, but developed countries showed a negative correlation between access to credit and marine productivity, because developed countries have already developed their fishery sectors to a degree that there are diminishing returns for increased investment. After controlling various economic and environmental variables along with political factors, the results remain robust in terms of sign and significance.

Jel Classification Code: Q22, G21
Keywords: Credit Access, Fisheries Production, Panel Data Analysis

Introduction

The Marine Economy plays a vital role in supporting communities across the world. This small and often unnoticed part of the economy plays a crucial role in the preservation of biodiversity in our marine ecosystems and our role in environmental conservation (Wang *et al.,* 2021). It is an indispensable part of the global efforts towards finding sustainable and inclusive economic development (Appiah *et al.,* 2025). The Marine Economy is the collection of small-scale fisheries that catch on the open ocean, and larger-scale aquaculture projects, which develop farms to *collect en masse*, and their relation to world trade (Stebbings *et al.,* 2020; Suresh, 2023; Colgan, 2013). Fishing is an unpredictable business, susceptible to both short-term and long-term shocks to its well-being, and thus needs credit to sustain itself, because when these shocks occur, these businesses require access to financial services to stay in operation (Pomeroy *et al.,* 2020). This paper seeks to answer three research questions: i) what the relationship is between households' access to credit and a country's marine productivity, ii) how being a landlocked country might affect this relationship, and iii) how being a developing country might affect the relationship between credit access and marine production.

Access to credit is a necessary part of the development of business and the formal economy (Suresh, 2023; Pomeroy *et al.,* 2020). It is key to many of the strategies for advancing financial development worldwide (Zinman, 2009). Uncertainty and the inability to access credit led to negative effects on productivity and growth (Koirala *et al.,* 2024; Jiang et al., 2025). They also lead to the development of an informal economy, which stunts the development of effective governmental reach and financial distribution (Pomeroy *et al.*, 2020). The presence of these informal credit systems is particularly common in the Marine Economy (Suresh, 2023). This creates a problem for governments, as the large presence of informal systems leads to a lack of trust in the state, which, in turn, makes it more difficult for governments to effectively implement policies that try to rectify this situation. It also creates more instability as those engaged in the informal financial system are not subject to the rule of law and are subject to the whims and caprices of loan sharks and other underground organizations.

The Marine Economy is a collective aggregate of economic activities of ocean-based establishments, employment, and productivity that trade around the world with one another (Colgan, 2013). They are in the business of catching, farming, and collecting marine wildlife to be sold for various purposes on the local, national, and international

markets (Suresh, 2023; Pomeroy *et al.,* 2020; Koirala *et al.,* 2024; Jiang *et al.,* 2025). Lack of access to credit leads businesses with limited options to obtain the quick financing they need to survive the shocks that frequently occur in this sector of the economy (*Pomeroy et al.*, 2020). This leads to businesses being squeezed when these shocks occur, resulting in the productivity of the Marine Economy falling (Jiang et al., 2025). This sets up the need to expand the accessibility of credit to serve as security against the instability of the market and the natural forces present in the marine economy. If businesses can find financial security, they are more likely to invest in the capital needed to expand their productivity in the marine sector.

The literature includes one paper that looks at how green finance affects China's Marine Economic productivity, using unique variables to measure out the relationship (Yi *et al.,* 2025). Another paper looks at the supply-side factors that constrict access to credit and their effect on the Marine Economy in 12 African countries (Appiah *et al.*, 2025). A paper looks at how blue finance affects the Chinese Marine Economy and its ability to sustain itself and the environment it inhabits (Jiang *et al.,* 2025). One paper looks at how financial developments affect the growth of the marine economy in China's 11 coastal regions. A paper looked at formal and informal financial systems and their effect on artisanal fishing operations in a southern state in India. Yet another study looks at how the lack of access to credit affects small-scale fisheries on an international scale (Pomeroy *et al.*, 2020). This paper instead looks at a much broader field of the marine economy by looking at all of the world's nations. This allows us to get a wider view of the marine economy that would not otherwise be achieved. This paper also specifically looks at whether being a landlocked country or a developing country affects this relationship.

Through thorough testing, our findings resulted in a positive and statistically significant correlation between household credit and marine productivity. This study also found that whether a country is landlocked or not did not have a statistically significant effect on the relationship between household credit and marine productivity. However, the results showed a statistically significant relationship in being a developed or developing country, with developed countries showing a significant negative relationship, and developing countries showing a significant positive relationship. All in all, this shows that increasing the credit available to the populace of a country increases their ability to produce in the marine sector of the economy by giving them access to greater pools of capital to which they can expand their productivity, and this is sound.

The rest of the paper is organized as follows: Section 2 covers the relevant literature, its findings, and its viability for this study, Section 3 describes the data, the variables, dependent, independent, and the control variables used in our equation, along with the methodology that is used to implement the regressions, Section 4 covers the results of

said regressions, and lastly Section 5 covers the conclusions that can be drawn from those results and the policies implications that can be derived from them.

Literature Review

Literature that explicitly follows the link between access to credit and the marine economy is primarily done using China as the country of study. The People's Republic of China forms the basis for most of the research done on this topic of how Credit affects the marine economy, probably because of funding for the subject by the nation to evaluate its own decisions in the area. Wang *et al*. (2021) sort out the real-life logic of finance's influence on the improvement of the marine economy's productivity and empirically test it using panel data through breaking down China into 11 distinct coastal regions from 2006 to 2016. They find that financial development does have a significant positive correlation with increased productivity in the marine economy. Yi et al. (2025) use those same 11 distinct coastal regions, considering their geographic advantages and the distinct resources they were endowed with, to look at the problem of access to credit and maritime economic growth from a green finance perspective and framework, to analyze the relation over an 11-year period from 2010 to 2021. They found that expansions in green finance had a significant positive correlation with maritime economic growth. Jiang et al. (2025) explored how blue finance impacts the quality of the environment of the marine economy, finding that blue finance has a positive and significant effect on the quality of the environment of the marine economy.

The problem can also be seen with some of the research with these two quotes from two separate research papers. They cover slightly different topics; one is about financial development's impact of the marine economy, while the other focuses on green finance and its impact on the marine economy, yet they both examine the exact same regions in China, these 11 coastal regions, meaning that the data from both is determined by the usefulness and reliability of the PRC's marine economic data, which can come under doubt because of the CCP's influence and notorious reputation for skewing their own economic data (Wang et al., 2021).

Some articles do manage to tackle this subject outside of the People's Republic of China. This study explored how supply-side factors were constraining credit to the Marine Economy through fisheries by banks in their selected African countries. Appiah et al. (2025) found that constraints on the variability in fish stock and the bank-to-cost income had a significant negative impact on the lending given out to the fisheries sector. Suresh (2023) explored how formal and informal credit systems affected artisanal fishing operations in a southern state in India, and Pomeroy et al. (2020) managed to look at the relationship between access to credit and small-scale fisheries on an international scale. These

studies found that factors related to the informal credit system perpetuate the informal credit system within artisanal fishing operations and that access to credit is positively and significantly correlated with the productivity of small-scale fisheries.

In regard to the financial literature, this paper draws upon quite a variety of topics regarding how finance is brought into topics, such as how Tulai et al. (2019) looked at the decentralization of Ukraine, Tran et al. (2018) looked at the impact of financial stress, among other factors, in the lives of college students, Suwanrada (2008) viewed the relationship between financial support and the condition of the elderly in Thailand, Ćumurović, and Hyll (2019) studied how financial support affects self-employment, Toke (2007) studied how financial services might be made to support the environment and meet renewable metrics such that they do not drag on the ecosystem, and Zinman (2009) looked at the restrictions on household credit access in Oregon. These financial studies serve as the basis for building how access to credit it measured, particularly in terms of household credit (Koirala et al., 2024).

In addition, there are also a select few solely on the marine economy, to cover the remainder of our bases, to make sure anything crucial is not missing when it comes to our discussion and research. Stebbings et al., 2020 cover the marine economies of the United Kingdom, which finds that the marine economy plays a greater role in overall economic development than previously thought through quantifying different aspects of the marine economy, Colgan (2013) covered the United States, which details the marine economy as a part of the overall economy and how it might be better managed through expanding data through looking at different parts of marine economic activity and how they might be quantified, and Surís-Regueiro et al. (2013) cover the European Union, which highlights the necessity to quantify the marine economy as a conceptual paper to help define aspects of the marine economy to research. These give us a look into how the Marine Economies of these countries and political blocs are measured.

While there is some concern of bias in some of the literature that has been written on the topic, the vast majority of papers that were used do the rigorous testing required and all the proper econometric formulas and equations needed to prove results worthy of research paper status. These studies make sure to use random sampling, use unique variables according to their situation, these variables have multiple factors built into them, and many of these studies show their errors when they occur, a sign of transparency with the audience. (Appiah et al., 2025; Yi et al., 2020; Wang et al., 2021; Stebbings et al., 2020; Surís-Regueiro et al., 2013; Colgan, 2013; Toke, 2007; Tulai et al., 2019; Tran et al., 2018; Lu et al., 2009; Suwanrada, 2008; Ćumurović and Hyll, 2019; Koirala et al., 2024; Jiang et al., 2025; Suresh, 2023; Pomeroy et al., 2020; Zinman, 2009).

It is the stated hypotheses, based on the literature cited, of this paper that:

> **Hypothesis 1:** Higher access to credit would lead to greater marine productivity, i.e., $\beta_1 > 0$

This was based on the theory that having higher access to credit would lead to the workers of a country having a greater ability to purchase the technology that they would need to scale their productivity, and that those countries with higher access to credit would have populaces with more advanced technologies that would allow them to scale their productivity better than countries with a more restricted access to credit (Suresh, 2023; Pomeroy *et al.,* 2020; Koirala *et al.,* 2024; Jiang *et al.,* 2025).

This access to credit would lead to an increase in access to capital, which, when deployed, would ease the labor requirements needed to produce in the Marine Economy. This then would increase each individual worker's productivity within this sector and thus would raise the nation's marine productivity. Contrarily, a restriction on access to credit would diminish or eliminate access to capital needed to ease the labor requirements needed to raise productivity, and thus the marine productivity of these nations with limited access to credit would stagnate or be diminished when compared to those nations with higher access to credit among their populations.

> **Hypothesis 2:** The relationship between households' access to credit and marine productivity should remain consistent regardless of whether a country is landlocked, non-landlocked, developing, or developed.

In general, from what the research has done, the location of a country or its development does not seem to have an effect on how credit access improves Marine Productivity. The papers on China, the African States, and the world showed roughly the same results despite being in different regions and at different points in economic development (Appiah *et al.,* 2025; Yi *et al.,* 2020; Wang *et al.,* 2021; Pomeroy *et al.,* 2020; Jiang *et al.,* 2025). Instead, we should see the same relationship between households' credit access and marine productivity, but merely on different scales, since landlocked and developing countries are going to have different scales of output compared to non-landlocked and developed countries, because of the lack of ocean and sea access for landlocked countries and the lack of industrial development for developing countries.

Data, Variable, and Methodology

Data and Variables

This study uses panel data as the metric of choice, with all of the world's countries paired up against a time frame from 1960 to 2024. There are gaps in this time frame when taken across the various variables, which are adjusted for. This panel set contains 72 countries and territories (N=72), of which 15 are landlocked, 57 are non-landlocked, 5 are

developed, and 67 are developing countries and territories. There is a total of 5 territories within the dataset. This is taken from a period of time from 1960 to 2024.

The main dependent variable is marine productivity. It is measured through the complete raw output of the world's listed fisheries, measured in the tonnage of fish caught within a given year. Because of the high output of some countries, the logarithm of this variable is taken. (Stebbings *et al.,* 2020; World Bank, 2025). With logarithms taken, values range from 3.95 to 17.01 metric tonnes with a mean of 11.23 and a standard deviation of 2.64. This and the following information may be found in Table 1.

The main independent variable is access to credit. This is measured as Household Credit, which is a measure of how much banks loan out to households, taken as a percentage of GDP, and this is taken from the World Bank's World Development Index. In particular, the World Bank measures the domestic credit given out from the financial sector to various households within a country, excluding the central government of a country (Koirala *et al.,* 2024;). values range from 1.58 to 5.98 with a mean of 3.98 and a standard deviation of 0.81.

The control variables are as follows: Research expenditure, which is the amount of money, relative to the GDP of a nation, that a nation spends on developing research. It shares an indirect relationship with the dependent variable because the more research is developed, the more new technologies are developed that could lead to new technologies that enhance the productivity of the fisheries of the world's nations. It is derived from the Our World in Data database (Our World in Data, 2025). Its values range from 0.005 to 3.586 with a mean of 0.599 and a standard deviation of 0.756. The emissions of carbon dioxide throughout the world are measured per capita through the amount of fossil fuels burned by the nations of the world. This shares an indirect relationship with the dependent variable because the rise in carbon dioxide can damage the ocean ecosystem, leading to a reduction in the amount of fish able to be caught and thus a decrease in the productivity of fisheries. It is derived from the Our World in Data database (Our World in Data, 2025). Values range from 0 to 85.56304 with a mean of 3.714 and a standard deviation of 6.031.

State Capacity, or how the measure of how rigorous and impartial a state's bureaucracy is, is also measured, taken from the Our World in Data database (Our World in Data, 2025). Values range from -3.273 to 3.281 with a mean of 0.169 and a standard deviation of 1.359. The protection of the rights of small-scale fisheries is measured through an index that is based on an analysis of the presence of relevant laws that adequately protect small-scale fisheries in a country by the Our World in Data database (Our World in Data, 2025). It is directly related to the dependent variable because the fisheries are not being protected from aggression, which goes on to hamper productivity. Values range from 1 to 5 with a mean of 4.059 and a standard deviation of 1.153. Another control variable is Trade Value, measured as the sum of exports and imports of goods and

services as a percentage of GDP. It is derived from the World Bank database (The World Bank, 2025). Values range from 5.727 to 274.973 with a mean of 66.118 and a standard deviation of 33.799. The last control variable is an index of Liberal Democracy, or how much a country upholds human rights, democratic principles, and free and fair electoral practices as outlined by the UN charters and modern philosophical thinking. Values range from 0.015 to 0.87, with a mean of 0.311 and a standard deviation of 0.251.

Table 1: Variable Descriptions and Averages

Variable	Description	Mean
Marine Production (million tonnes)	The measure of a country's total marine output from its fisheries.	1.039
Household Credit	How much banks lend to households as a percentage of GDP	26.92%
State Capacity	A score of how rigorous and impartial a nation's public administration is.	0.169
R & D as % of GDP	A measure of how much research and development spending accounts for the % of GDP.	0.60%
Carbon Emission (metric tonnes)	A measure of annual CO2 emissions per capita in a given country.	3.71
Rights of Fisheries	An index measuring the degree to which a country protects the rights of fisheries.	4.059
Liberal Democracy	An index measuring a country's application of democratic principles and upholding of human rights.	0.311
Trade Value	Sum of Imports and Exports as a percentage of GDP	66.12%

The graph, Fig. 1, details every country found in the World Bank's World Development Index's marine productivity from high to low. There are a total of 217 countries and territories within this graph. The countries are split into two categories: landlocked, those countries without a coastal border, and non-landlocked, those countries with a coastal border. The average marine productivity is taken from the data to give a single overview of each country's standing in terms of its marine productivity. Each country is put on a scale from low to high and is marked with a shade depending on its 1. marine productivity and 2. its landlocked status. These values range from a minimum of 0 to a maximum of 32,789,106 tonnes for non-landlocked countries and 268,719 for landlocked countries. This relationship can be seen if we take a look at two countries that are nearby one another yet have some geographical differences, Kazakhstan and Mongolia. From the graph, it can

be seen that Kazakhstan has a greater marine productivity than Mongolia, which makes sense when you consider that Kazakhstan has access to an inland sea along with being a bigger country with more lakes, while Mongolia is mostly wild steppe lands punctuated by desert and steep mountains.

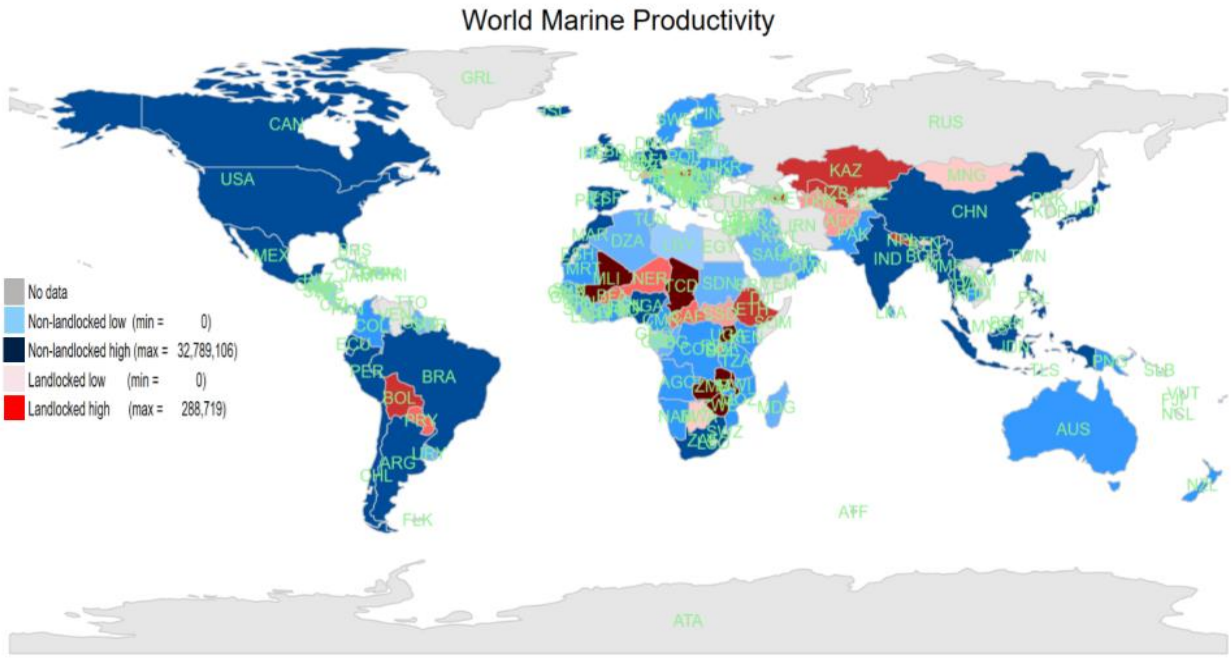

Figure 1: World Map of Average Marine Productivity in Landlocked and Non-landlocked Countries[1]

Landlocked and non-landlocked countries were separated into zones. This means that a dark shade in a landlocked country is not equal to a dark shade in a non-landlocked country. The two distinctions are built on their own scales. In landlocked countries, you have a scale of red, and in non-landlocked countries, you have a scale of blue. Lighter shades are given to countries with lower marine productivity, and higher shades correspond with greater marine productivity. Countries in gray are those for which there was no data available. Countries are also delineated with their corresponding ISO3 country code to label them for the graph.

This graph, Fig. 2, depicts the bivariate relationship between Access to Credit and the Marine Economy, taken from all countries [2]with data available in both household credit

[1] ISO3 country codes are what the World Bank uses to delineate countries. They appear in green on the graph.

[2] There are graphs done in this style for unique situations, such as landlocked vs. non-landlocked, and devolved vs. developing countries, which may be found in the appendix portion of the paper.

and marine productivity. This bivariate relationship was built by taking the average of each country's data in each variable. Countries without data in either of the two datasets are excluded. Each country has its data sets reduced to a single point by taking the mean of each of its data points. This is done so that the graph isn't cluttered with thousands of points on the scatterplot. Household credit and marine productivity continue to follow the same rules as exposited in the data section, beyond the change mentioned just previously. Logarithms of both variables were taken for the conciseness of the graph.

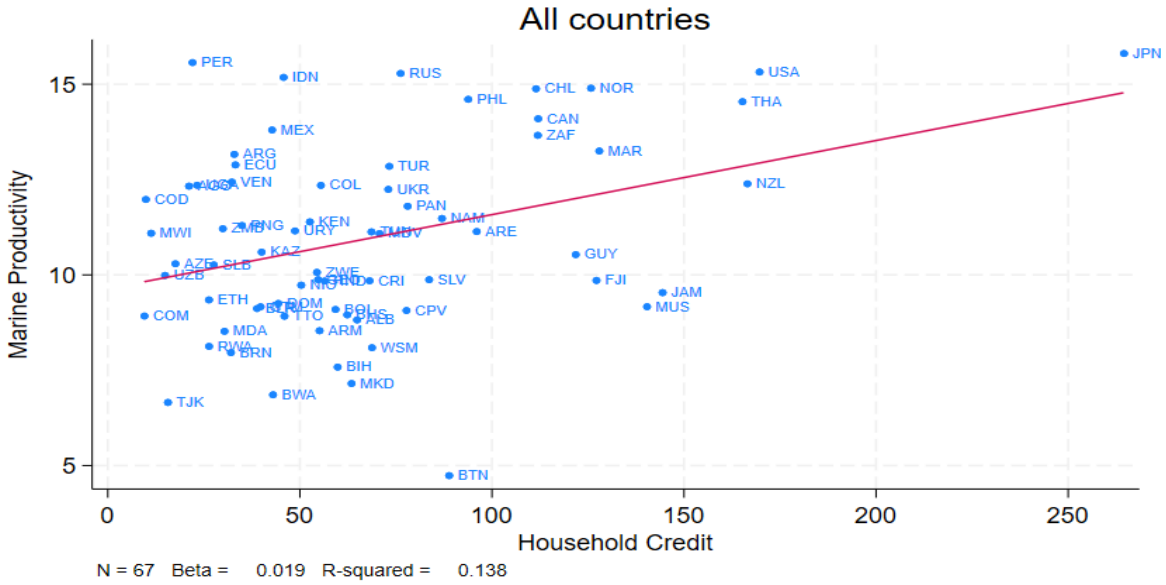

Figure 2: Correlation between Access to Credit and Marine Productivity for All Countries[3]

Through this graph, it is found that there is a general positive correlation between access to credit and the marine economy, and such a response is expected from further regressions done on this model. There are a few outliers in terms of marine productivity, with Japan, Indonesia, and Peru scoring well above the other countries. Japan is also an outlier in terms of access to credit as well. With the reductions to a single point, it can be seen that 67 countries made it to this graph, which are taken as a given to represent the world in this research, given the limitations in data.

[3] Since ISO3 Country Codes do not count for territories, they were eliminated when devising this graph. This is why the number has dropped from 72 to 67.

Econometric Model

Next is to explore the econometric model built for this study. This model is built to show the statistical relationship between household credit and marine productivity. It is built based on the standard fixed effects model.

$$log(MarineProd_{it}) = \beta_0 + \beta_1(Credit_{it}) + X'_{it}\gamma + n_t + p_i + \epsilon_{it} \quad (1)$$

Following the platform model, our model takes the logarithms of marine productivity, keeping household credit linear, with marine productivity being our dependent variable and household credit being our independent variable in this model.

Household credit ($Credit_{it}$) is our metric for measuring a nation's access to credit and is our primary variable of interest. In our log-level form, which is done because of the few outliers found in Fig. 2, the coefficient on $Credit_{it}$, β_1, is taken to show the semi-elasticity of household credit with respect to marine productivity. This semi-elasticity shows the percent change in marine productivity when household credit increases by one percentage point.

X'_{it} is a vector for our control variables. This variable is built primarily on the GDP, Population, Trade Value, and Carbon Emissions control variables, but contains the rest of them as well. These variables were defined in the data and variables section of the paper.

To test the robustness of our test, the control variables mentioned above are included. Finally, n_t and p_i control for time and country-specific effects, respectively, and ϵ_{it} is our error term, capturing the omitted variables and noise.

Results and Discussion

For this study, two different regression tests were performed on the panel data acquired for the study: Pooled OLS and Fixed Effects (FE). We give more emphasis on the Fixed Effects test results, since this is what the literature recommends using to achieve plausible results under general assumptions (Judge *et al*., 1991). The simple Fixed Effect model was used as the regression of choice. This is also reinforced by the measurements that are achieved with the test used to reinforce and verify the statistical significance of our regression results.

Following the first model, without any controls added, using both the fixed effects model and pooled OLS as a baseline, the results show that our coefficient is at 0.0006 and 0.0159, respectively, indicating that with a one percentage increase in the credit given out to households, the results find a 0.06% and 1.6% respective increase in marine productivity (Yi *et al.,* 2020; Wang *et al.,* 2021; Pomeroy *et al*., 2020; Jiang *et al*., 2025). The

constants for this baseline result were 10.88 and 12.00, respectively, for the pooled OLS and the Fixed Effect model. These baseline results support and reinforce our hypothesis before controls are added, which are done in a stepwise manner.

Adding more controls both added significance to the relationship between household credit and marine productivity, along with maintaining the positive correlation set out by the first model that was tested. Coefficient estimates range from 0.00385 to 0.0118 for the OLS regressions and 0.0017 to 0.003 for the Fixed Effect model. Overall, these points reinforce the main hypothesis that was developed. Out of necessity for observation counts, 7 variables out of the total of 12 were used since issues with multi-collinearity would cause observation counts to collapse or cause regression results to become skewed. In particular, certain uses of variables based on GDP metrics would cause issues in the Fixed Effects model, so they were removed from the regression model to preserve stability and unbiasedness.

Table 2: Regression Results of Pooled OLS for Credit and Marine Production

VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Credit Access	0.015***	0.011***	0.0108***	0.010***	0.0118***	0.007***	0.00385
	(0.0008)	(0.0009)	(0.001)	(0.000)	(0.002)	(0.002)	(0.01)
State Capacity		0.482***	0.405***	0.196***	0.250***	-0.291	-0.295
		(0.053)	(0.057)	(0.0546)	(0.0801)	(0.182)	(0.632)
Carbon Emissions			0.0434***	0.0572***	0.0401*	0.0665***	0.169
			(0.0123)	(0.0138)	(0.0233)	(0.0244)	(0.166)
Trade Value				-0.0230***	-0.0282***	-0.0237***	-0.00881
				(0.001)	(0.00278)	(0.003)	(0.014)
R & D % of GDP					-0.173	0.100	0.221
					(0.253)	(0.264)	(1.356)
Liberal Democracy						2.985***	1.896
						(0.906)	(3.551)
Rights of Fisheries							0.676**
							(0.319)
Constant	10.88***	11.02***	10.94***	12.77***	13.06***	11.73***	8.567***
	(0.0855)	(0.0883)	(0.0911)	(0.139)	(0.257)	(0.477)	(2.566)
Observations	1,454	1,252	1,252	1,079	498	498	38
R-squared	0.180	0.248	0.255	0.395	0.460	0.472	0.411

Note: The values in parentheses show robust standard errors. *, **, and *** show significance at the 10%, 5% and 1% levels respectively.

Based on the simple fixed effect model that is shown below in Table 3, the amount a country spends on research and development as a percentage of GDP turned out to be insignificant, showing it doesn't have much effect on the relationship between household credit and marine productivity. Carbon Emissions showed a significant positive correlation, and though this isn't seen explicitly in the literature cited, this can be seen as a sign of industrial development, which is shown to improve productivity both in the marine economy and the economy more broadly, and since most of the countries measured here are developing economies, this boost is giving them the growth they need before they hit the drawbacks of increased pollution, if the study was carried on into the far future, the data would likely see this trend reverse (Yi *et al*., 2025). Trade value shows a marginally significant positive result, showing that increases in trade will increase marine productivity (Stebbings *et al*. 2020).

Table 3: Regression Results of Fixed Effect for Credit and Marine Production

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Credit Access	0.00058	0.0025***	0.0029***	0.0029***	0.0029***	0.0028***	0.0016
	(0.0003)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.002)
State Capacity					0.0421	0.00580	-0.0636
					(0.0388)	(0.0539)	(0.169)
Carbon Emissions			0.0259***	0.0669***	0.0623***	0.0649***	0.211*
			(0.009)	(0.018)	(0.018)	(0.018)	(0.110)
Trade Value				0.00233*	0.00235*	0.00222*	7.10e-05
				(0.00123)	(0.00123)	(0.00124)	(0.00269)
R & D % of GDP		-0.119	-0.104	-0.0447	-0.0260	-0.0202	-0.119
		(0.110)	(0.110)	(0.112)	(0.113)	(0.113)	(0.432)
Liberal Democracy						0.220	0.143
						(0.227)	(0.559)
Rights of Fisheries							0.0546
							(0.0444)
Constant	12.00***	12.20***	12.00***	11.67***	11.64***	11.57***	11.28***
	(0.0304)	(0.0751)	(0.105)	(0.166)	(0.168)	(0.185)	(0.656)
Observations	1,454	514	514	498	498	498	38
R-squared	0.002	0.017	0.032	0.055	0.058	0.059	0.511

Note: The values in parentheses show robust standard errors. *, **, and *** show significance at the 10%, 5% and 1% levels respectively.

The state capacity, liberal democracy, and small-scale fishery rights control variables all turned out to be insignificant factors in the relationships between household credit and marine productivity. This means that how robust a nation's public administration is, how incorruptible they are, and how much they develop protections for small-scale fisheries, while having a positive effect on marine productivity, does not have any meaningful impact statistically speaking. Values of R-squared range from 0.180 to 0.472 in the Pooled OLS model and range from 0.002 to 0.511 in the Fixed Effect model.

From the table, the results prove that there is a significant positive correlation between access to credit and marine productivity. Stronger statistical significance is found in the pooled OLS model over the Fixed Effect model, but we do find statistical significance

there, too. It is important to note that even with the variables removed that were causing unacceptable losses in observation counts, there is still some loss in observation count across the stepwise model, the clearest example being the small-scale fisheries rights control variable. This is because this metric is something that has begun research recently and was not done every year, leading to a limited amount of overlap with other datapoints with the rest of the equation.

These results suggest that with increases in the amount of credit households have access to, there is a significant correlation to increases in marine productivity. Of note is the decrease in observation count towards the latter end of the stepwise regression. This is the reason some of the control variables were dropped since they lacked overlapping data, which would cause issues in the regression process, especially since adding some controls with one another would sometimes cause observation counts to drop to zero. This signifies the importance of continued research into the multifaceted arena that is the question of access to credit and marine productivity.

Three of these tests were used: the F-test, the Breusch-Pagan LM, and the Hausman test, measuring variance, heteroskedasticity, and endogenous regressors, respectively. Since the Bresch-Pagan LM test returns 0.0007, which is less than 0.05, it can be concluded that the F-test is marginally better than the Pooled OLS model at being a good fit for the data that has been compiled. With the Hausman test returning a value under $p<0.05$, we can reject the null hypothesis and conclude that the F-test is the better fit regression model for the data that this study is analyzing.

Robustness Analysis

To test the robustness of our regression model, countries were broken down into two groups of pairs. The first group breaks down countries based on whether they are landlocked or whether they are a non-landlocked country. The second group focuses on whether a country is considered developed or whether they are developing. The regression is performed keeping in mind the limited number of observations in the groups with fewer countries.

Table 4: Landlocked VS Non-Landlocked Countries: Credit and Marine Production

VARIABLES	Landlocked Countries	Non-landlocked Countries
Credit Access	0.0282***	0.00188**
	(0.00624)	(0.000934)
State Capacity	-0.197	0.0185
	(0.199)	(0.0543)
Carbon Emissions	0.000900	0.0611***
	(0.0578)	(0.0195)
Trade Value	-0.00768**	0.00288**
	(0.00327)	(0.00136)
R & D % of GDP	-2.287	0.0453
	(1.417)	(0.110)
Liberal Democracy	-0.190	0.0542
	(0.992)	(0.231)
Constant	9.428***	12.08***
	(0.539)	(0.207)
Observations	66	432
R-squared	0.414	0.047

Note: The values in parentheses show robust standard errors. *, **, and *** show significance at the 10%, 5% and 1% levels respectively.

The results of this regression reinforce the trend that was seen earlier (Jiang *et al.*, 2025; Yi *et al.*, 2025), with a significant positive correlation between household credit and marine productivity. Coefficients are at 0.028 and 0.002 for landlocked and non-landlocked countries, respectively, showing that for landlocked countries, each standard deviation increase in household credit leads to a 2.8% increase in marine productivity and a 0.2% increase for non-landlocked countries. R-squared is at 0.414 and 0.047 for landlocked and non-landlocked countries, respectively. An interesting development is that many of the control variables have contrary effects within landlocked and non-landlocked countries on the relationship between household credit and marine productivity, though most of these lack significance in their effects, so this ought to be taken with caution.

While developing countries continue the trend that was seen previously, developed countries buck this trend with a significant negative correlation, though this result must be taken with a grain of salt. Although observations are at 91, as can be seen in Fig. 5 in the appendix, there are only 5 countries that contain the overlapping data required to survive

to this stage, so these results, which are only significant at the 10% level to begin with, only hold true when looking at Japan, the United States, Norway, New Zealand, and Canada. Coefficients stand at -0.001 for developed countries, and 0.007 for developing countries. R-squared sits at 0.453 and 0.126, respectively, and constants are at 15.47 and 10.83, likewise.

The disparity in observation counts is due to differences in the number of non-landlocked and landlocked countries in the world (Pomeroy *et al*., 2020). This is also the reason for the absence of some of the control variables, since the limited number of observations caused by the small number of countries and lack of overlapping data eliminates them completely. This is also apparent in the difference in observation counts between developed and developing countries. This is important to keep in mind when looking at the results.

Table 5: Developed vs. Developing Countries: Credit and Marine Production

VARIABLES	Developed Countries	Developing Countries
Credit Access	-0.000943*	0.00707***
	(0.000480)	(0.00141)
State Capacity	-0.110	0.0657
	(0.0702)	(0.0601)
Carbon Emissions	0.00312	0.0915***
	(0.0145)	(0.0329)
Trade Value	-0.0143***	0.00302**
	(0.00216)	(0.00134)
R & D % of GDP	0.0136	-0.0902
	(0.0718)	(0.152)
Liberal Democracy	0.915	-0.0287
	(0.590)	(0.249)
Constant	15.47***	10.83***
	(0.538)	(0.172)
Observations	91	407
R-squared	0.453	0.126

Note: The values in parentheses show robust standard errors. *, **, and *** show significance at the 10%, 5% and 1% levels respectively.

It should also be noted that a number of countries were excluded from the regression data because of their lack of household credit data, including China, which was a notable outlier regarding marine productivity, and this could change how the relationship between access to credit and marine productivity plays out. Lack of overlapping data is the main cause for the drop in observation counts, which suggests that further data should be collected to expand this research and to provide a more precise and accurate showing of the relationship between access to credit and marine productivity (Pomeroy *et al*., 2020).

Since, by calculating the total number of countries in the U.N. multiplied by the timeframe of the dataset, there is a total possible observation count of 12,480, the data collection has a long way to go.

Conclusion and Policy Implications

This paper investigates the relationship between household credit access and marine productivity. The proposed hypothesis is that fishermen need access to credit to continue and expand their operations within the marine economy, and that expanding access to credit would give them the ability to purchase the capital and technology required to expand their operations and make them more efficient, thus increasing their productivity. This hypothesis was further expanded on by considering the impact that a country being landlocked or non-landlocked, or being developed or developing, would have on this relationship. The data comprises 72 countries and territories over a period stretching from 1960 to 2024, showing statistically significant results that household credit access has a positive correlation with marine productivity. The empirical results showed that for a one standard deviation increase in the credit access given to households, there is a corresponding increase by 0.3%. With this in mind, there are some notable limitations that need to be highlighted. This study mainly focuses on the relationship between the credit given to households and their relation to marine productivity, since households are not the only factor of those employed within the marine economy; it may be worth researching the relationship between larger operations' credit access and its impact on marine productivity. Second, since marine productivity is measured through fishery productivity, it does not completely scale the full scope of the marine economy, since there are other factors, including the larger-scale aquaculture operations mentioned previously. Third, endogeneity remains unresolved, so while these results prove a correlation, they do not prove a definitive causal relationship. This is an important step in future research.

An increase in a household's access to credit, on average, raises a nation's marine productivity due to a) the availability of capital being increased from the increased credit access, b) the increase in business opportunity to allow for sustained and expanded operations from increased credit access, allowing for more security as a cushion, and c) the increase in technological development reducing the labor requirement for fisheries, thus raising the productivity (Jiang *et al*., 2025; Yi *et al*., 2025; Wang *et al.,* 2021). This marine productivity can then serve to increase the food supply or be sold abroad to increase the nation's overall productivity.

Although this paper provides statistically significant evidence of a robust link between household credit and marine productivity, further levels of analysis are a necessary step to fully explore the link and to discover more channels of interest. Exploring these alleys

provides encouraging reinforcement for further research on the topic (Pomeroy *et al*., 2020). Different alleys can include a greater research focus on small-scale fishery rights, developing greater credit data on the household level in both the developed and developing world, and a greater focus could be put on examining the relationship between landlocked countries' fisheries and how their access to credit allows them to contribute to the marine economy (Pomeroy *et al*., 2020).

In terms of the policy implications, given the positive correlation shown, should a nation wish to expand its marine productivity, it ought to expand households' access to credit. This can be done by using biodiversity credit, which is a market-based mechanism that allows the government to offer credits to those who expand productivity while building biodiversity and contributing to conservation efforts (The Nature Conservancy, 2024). This would allow for increased credit access to expand productivity while also making sure that such expansion remains sustainable for the environment, so that it would be a long-term solution. Another solution would be to offer low-cost loans through public-private blended finance, which, as the name implies, blends public and private credit offerings to expand credit access and credit flows to expand markets in desirable sectors. It is often used to draw funding to sectors that would otherwise not receive credit under traditional market circumstances by mitigating risk. It is also used in green finance initiatives and with targets against climate change and for providing sustainable objectives, which is key for the long-term sustainability of the marine economy (World Bank, n.d.).

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Appendix

Region	Landlocked Countries in World[4]
Africa	Botswana; Burkina Faso; Burundi; Central African Republic; Chad; Ethiopia; Lesotho; Malawi; Mali; Niger; Rwanda; South Sudan; Uganda; Zambia; Zimbabwe
Europe	Austria; Czech Republic; Hungary; Luxembourg; North Macedonia; Serbia; Slovakia; Switzerland
Asia	Afghanistan; Armenia; Azerbaijan; Bhutan; Kazakhstan; Kyrgyzstan; Laos; Mongolia; Nepal; Tajikistan; Turkmenistan; Uzbekistan
South America	Bolivia; Paraguay

Region	Developed Countries[5]
Europe	Austria; Belgium; Bulgaria; Croatia; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Norway; Poland; Portugal; Romania; Slovakia; Slovenia; Spain; Sweden; Switzerland; United Kingdom
Asia	Australia; New Zealand; Japan; South Korea
North America	Canada; United States

[4] We could not take all landlocked countries in our sample due to unavailability of credit access data.
[5] We could not take all developed countries in our sample due to unavailability of credit access data.

Table 6: Summary Statistics of All Variables

Variable	Mean	Median	Std Dev	Min	Max
Marine Production	11.22832	11.09949	2.637992	3.951244	17.01645
Household Credit	26.92	24.54	17.52	0	89.91
State Capacity	0.169214	0.004	1.359148	-3.273	3.281
R & D as% of/GDP	0.598789	0.31233	0.756171	0.00544	3.58623
Carbon Emission (CO_2)	3.714046	1.623033	6.030891	0	85.56304
Rights of Fisheries	4.058824	4	1.15319	1	5
Liberal Democracy	0.311049	0.237	0.250505	0.015	0.87
Trade Value	66.11806	59.36075	33.79858	5.726872	274.9731

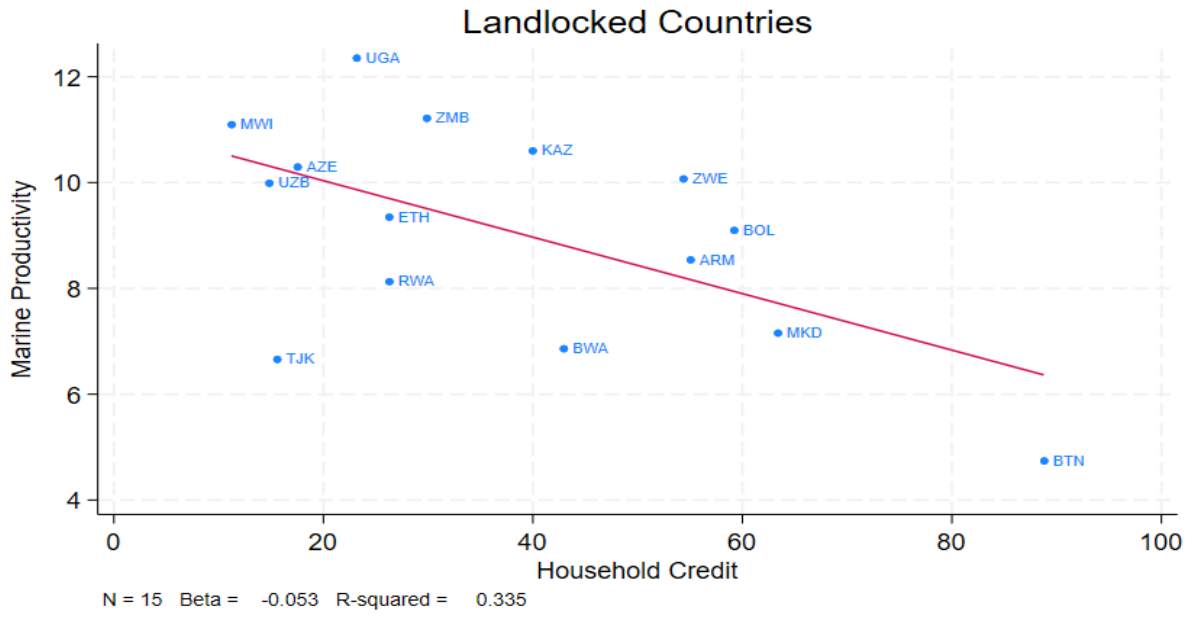

Figure 3: Correlation between Access to Credit and Marine Productivity for Landlocked Countries

This graph depicts the bivariate relationship between Access to Credit and the Marine Economy for those countries that are landlocked and do not have access to the open ocean or a sea that has access to the open ocean. There are 17 landlocked countries, and

each variable has its data compiled into a mean, so that each country has one point on the scatter plot. This is done in the same vein as Figure 2, for questions on how it was done, it is to be referred to.

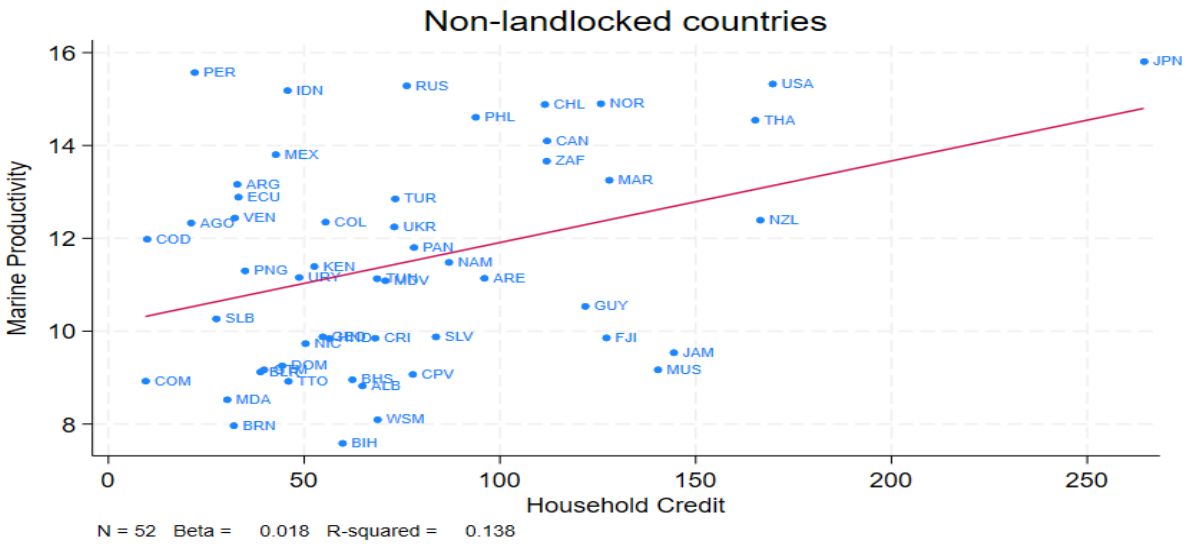

Figure 4: Correlation between Access to Credit and Marine Productivity for Non-Landlocked Countries

This graph depicts the bivariate relationship between Access to Credit and the Marine Economy for those countries that are not landlocked and do have access to the open ocean or a sea that has access to the open ocean. There are 50 non-landlocked countries, and each variable has its data compiled into a mean, so that each country has one point on the scatter plot. This is done in the same vein as Figure 2; for questions on how it was done, it is to be referred to.

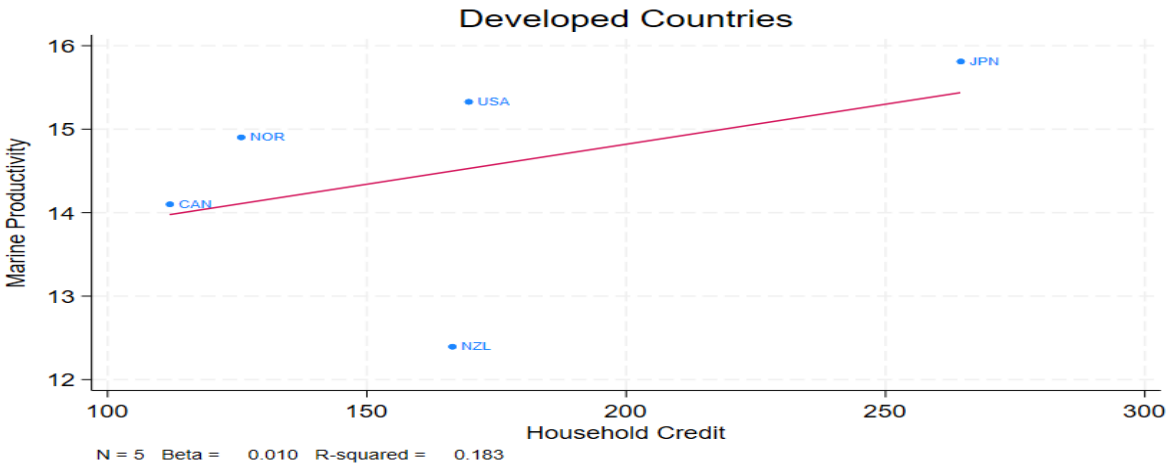

Figure 5: Correlation between Access to Credit and Marine Productivity for Developed Countries

This graph depicts the bivariate relationship between Access to Credit and the Marine Economy, for those countries that are considered developed by the World Economic and Situations Prospect Report, United Nations (2026). There are 5 developed countries that had data in both household credit and marine productivity, and each variable has its data compiled into a mean, so that each country has one point on the scatter plot. This is done in the same vein as Figure 2; for questions on how it was done, it is to be referred to.

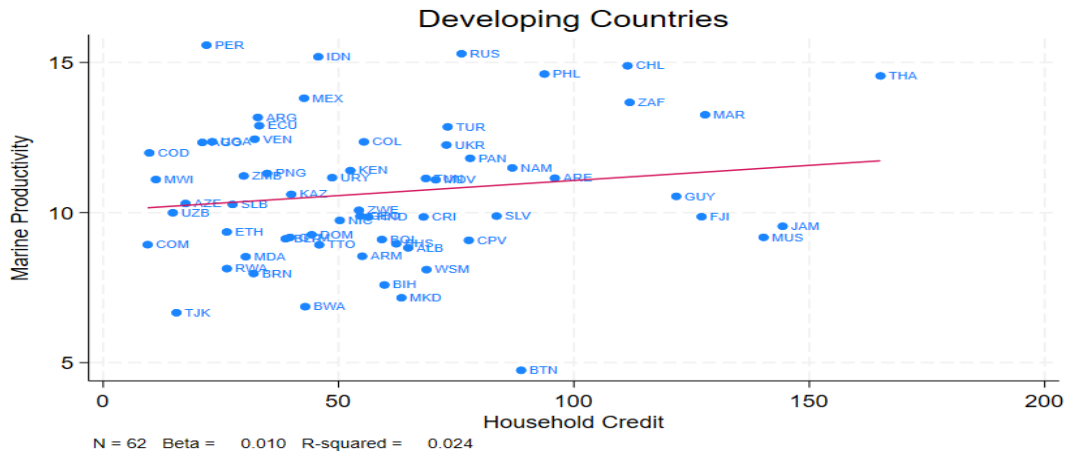

Figure 6: Correlation between Access to Credit and Marine Productivity for Developing Countries

This graph depicts the bivariate relationship between Access to Credit and the Marine Economy, for those countries that are considered developing by the World Economic and Situations Prospect Report, United Nations (2026). There are 62 developing countries that had data in both household credit and marine productivity, and each variable has its data

compiled into a mean, so that each country has one point on the scatter plot. This is done in the same vein as Figure 2; for questions on how it was done, it is to be referred to.