Evaluating local impacts of marine-based economic stimulus policies amid market imperfections in rural Indonesia

Working Paper

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Abstract:

Countries all over the world have pledged commitments to managing marine ecosystems in a way that promotes both conservation and sustainable development. The Indonesian government has been a leader, introducing its Blue Economy Initiative at Rio +20 in 2012, a paradigm prioritizing marine policies that encourage sustainable development of fisheries. However, marine-based economic stimulus policies are often implemented without addressing underlying causes leading to overharvest and ecosystem degradation. At the same time, other factors common to rural economies in developing countries, such as incomplete markets, can further distort household response to marine development policies. Utilizing a one-of-a-kind household and local-economy data set, we measure direct and indirect effects of marine-based economic stimulus programs on a rural coastal community and its ecosystems using a bioeconomic, general equilibrium model. Through simulation of the structural model, we illustrate the local impacts of one of Indonesia's recent marine fisheries policies: provisioning of fishing boats, engine and gear to support offshore fisheries. The steps taken to characterize fishing production and household capital allow us to depict household response to policies, demonstrating to what extent supporting small-scale fishermen can achieve poverty alleviation and conservation objectives. Estimates of local economy-wide effects can help us re-examine blue policy initiatives being employed in developing countries around the world.

Introduction

Indonesia's rich endowment of natural capital, including its fisheries, forests, and mineral deposits, have fueled economic growth over the past several decades. A prominent player in global fish production, Indonesia is one of the largest producers of marine capture fish. Indonesia's marine capture fishing fleet is dominated by small-scale or artisanal fishermen, responsible for the majority of the country's marine fish harvest. In addition to its role in global fisheries production, Indonesia is part of the Coral Triangle, a center of marine biodiversity, a global conservation priority for many organizations such as the UNDP, NOAA, World Wild Life Fund, Fauna & Flora International, and Conservation International. Decades of unchecked economic growth have led to vast environmental degradation (OECD 2015, UN CDS 1997), and drawn significant levels international funding and research devoted to improving conservation, achieving varying degrees of success (Whitten et al. 2001). To address these challenges, Indonesia has recently renewed and redefined its interest in sustainable development, focusing on the potential of its marine fisheries sector.

The Indonesian government introduced its 'Blue Economy Initiative' at Rio +20 in 2012, a paradigm prioritizing marine policies that encourage the development of marine fisheries, marine conservation, and cultural appreciation. Countries all over the world have followed suit, pledging commitments to managing marine ecosystems in a way that encourages both conservation and sustainable development. Indonesia's national government and its Ministry of Marine Affairs have been promoting programs and policies that improve trade infrastructure, curb illegal fishing, and encourage marine fisheries production. Using a hybrid bioeconomic local economy model, this paper develop methodology to explore the potential local economy effects of one of these marine fisheries policies: pelagic boat and gear provisioning targeting small-scale fishermen.

Marine-based economic stimulus policies that are implemented without addressing underlying market failures may further exacerbate overharvest and ecosystem degradation. Without clearly defined or enforced property rights, many of Indonesia's fish stocks are appropriately described as open access resources. Non-excludability and rival characteristics of local and regional fisheries lead to market inefficiency if not regulated by users (Stavins 2011, Ostrom 2008, Hardin 1968, Gordon 1954). Fishing households will allocate labor and capital disregarding the impacts on other fishermen and future fish stocks. Too many unregulated resource users drive the fishery stocks to inefficiently low levels, yielding low returns to fishers' labor and capital. If we additionally observe an imperfect output market for fish, the depleted fish stock caused by over harvest may additionally lead to a high local price, to the detriment of all households consuming fish in the local economy.

Market imperfections that cause prices to be determined within a local economy create interdependencies between households and economic sectors. Thus, marine policies targeting fishing households in a rural economy may have local general equilibrium effects. The local general-equilibrium framework must embed household models when households face imperfect factor markets and vary in their endowments of these factors (Taylor and Adelman 1996). Modeling the local economy allows for the examination of both the direct impacts of policies and indirect impacts of policies due to these interdependencies.

Modeling village general-equilibrium effects can also highlight the connection between economic activities and natural resource stocks. A non-regulatory way to encourage fishermen to exit an over-exploited fishery is to provide, or enhance existing, alternative livelihood opportunities. Manning et al. (2013) introduce an open access fishery to a single period local general-equilibrium model, illustrating the ambiguous effects of increasing agricultural prices when factor and output markets are imperfect. Gilliland et al. (2016) develop a dynamic local general-equilibrium model with an open access fish stock in order to illustrate the biological and economic impacts of a growing tourism sector in the Philippines. In Indonesia, marine fisheries stimulus policies are used as a tool to encourage fishermen to move into offshore fisheries, in hopes of relieving the burden of overfishing of nearshore fish stocks. This research will consider the household's incentive to leave one open access fishery for another.

This research considers fishing households that face multiple factor market imperfections which could play off one another. Amid credit and labor market imperfections, the value of an agricultural household's alternative labor option depends on initial endowment of productive assets (e.g. Carter and Zimmerman 2003, Zimmerman and Carter 1999, Eswaran and Kotwal 1986, 1989). Despite low returns to factors of production in an open access fishery, households with limited options may be incentivized to boost short-run returns by investing in fishing capital because returns to labor are tied to capital ownership. While related work has demonstrated the connection between a fisherman's shadow wage and fishing effort in an open access fishery (as in Manning et al. 2013, Cinner et al. 2008, Liese et al. 2007), we emphasize the ways in which capital market imperfections hinder households' ability to reallocate labor to alternative production activities.

Our study further develops the hybrid model of a Local Economy-Wide Impact Evaluation (LEWIE) model of a small, rural economy and a dynamic biological model of near-shore fisheries (together called a Bio-LEWIE) developed by Gilliland et al. (2016). A LEWIE model is an applied computable general equilibrium (CGE) model that represents key components of an isolated economy, including key production activities, relationships between households, and market imperfections (Taylor and Filipski 2014).

Whereas pervious research has modeled a single aggregate fishing activity, our framework distinguishes between nearshore and offshore fishing activities, allowing us to disentangle multiple economic and biological impacts of marine policies. We also contribute to the literature by refining the model of household capital stocks and investment decisions. Our model is applied to a case study of a rural coastal community in eastern Indonesia, parameterized and calibrated using an original data set of households and business surveys. While the model is developed to capture one particular local economy, insights can illuminate the impact how similar marine policies affect local economies throughout Indonesia and the developing world.

The Model

While marine-based economic stimulus policies are being implemented throughout the Indonesian archipelago, this research focuses on Selayar Island, the main island of Selayar District, located just south of Sulawesi Island. Main economic activities include marine capture fisheries and agriculture. Fishing households participate in both pelagic and nearshore fishing. Agricultural activities include the harvest of crops including coconuts, cashews, cloves, grains, vegetables and fruit. Selayar is an isolated economy within a country characterized by limited trade- and transport-related infrastructure. Because households of Selayar face high transaction costs, imperfect and missing markets, a Bio-LEWIE model is well suited to demonstrate how marine policies will impact fisheries and Selayar Island's economy and more generally, to develop insights into the effects of government interventions on rural coastal economies.

To estimate the biological and economic impacts of marine capital subsidy policies we link a disaggregated local economy-wide model with a bioeconomic model of local fisheries. The model captures linkages between households and within household production activities due to imperfections in factor and output markets. The model also accounts for intertemporal changes in fish stock; harvest in period *t* impacts the available fish stock in period *t+1*, which in turn impacts harvest in period *t+1*. In this section, we describe the local economy model and the connection to local fish populations, as well as how it is used for policy analysis.

Local Economy-Wide Model of Selayar:

The local economy-wide model of Selayar is a computable general equilibrium model of a small economy, parameterized with data from site-specific household surveys. We have chosen to model four representative households, defined by livelihood and poverty status: poor fishing households, non-poor fishing households, poor non-fishing households, and non-poor non-fishing households. Households reporting one or more active fishermen are designated as a fishing household. Households with per capita consumption expenditure below the Indonesian National Poverty Threshold are designated as poor households. Each representative household is characterized by production functions, intermediate and factor demands, consumption functions, and consumption demands. A set of household and market clearing conditions ensure the economy is balanced and representative of the community.

For Selayar, we have defined six production activities in which households can participate: Agriculture and livestock, nearshore fishing, offshore fishing, restaurants, retail, and other services. Restaurants have been modeled separately from other entrepreneurial activities because they demand a higher level of fish as intermediate inputs. Separating this activity will provide a better indication of how restaurants are impacted by marine capital subsidy policies and subsequent changes in local fish stocks.

All production activities are assumed to follow Cobb-Douglas production with constant returns to scale. Non-fishing production can be expressed formally as,

$$Y_{i,t} = A_i \Pi_f FD_{i,f,t}^{\beta_{i,f}} \;, \qquad s.t. \Sigma_f \beta_{i,f} = 1 \;\forall\; i \tag{1}$$

where $Y_{i,t}$ is output in sector i in time t, a function of the f factor demands $FD_{i,f,t}$. For each production activity and factor input, the parameter $\beta_{i,f}$ represents the output elasticity. Factors of production include labor, capital, and land. The factor demands for each production activity can be expressed as,

$$FD_{i,f,t} = \frac{Y_{i,t} PVA_{i,t} \beta_{i,f}}{w_{f,t}} \tag{2}$$

where PVA_{it} is the price value added for good i at time t, and $w_{f,t}$ is the price for factor f at time t. Intermediate demands are assumed to follow Leontif processes.

Nearshore and offshore fishing are modeled as separate income-generating activities. It is assumed that each production activity produces just one output: nearshore fishing yields nearshore fish and offshore fishing yields offshore fish. Though output markets may be separate, production is linked; fishing households do not typically employ selective fishing gear and fishing strategies. The most common forms of fish gear are pole and lines, spear guns, gill nets, and purse seine nets. A variety of boats may be used for both nearshore and offshore fishing, although offshore fishing activities tend to rely on larger fishing boats.

When modeling the two fishing production activities, fish stocks are treated as additional factors of production. Nearshore fish and offshore fish are assumed to have separate fish stocks. As such, the two fishing activities may be expressed as,

$$Y_{F,t} = A_F \Pi_f FD_{F,f,t}^{\beta_{F,f}} * X_{F,t}^{\beta_{F,X}} \quad , \qquad s.t. \Sigma_f \beta_{F,f} + \beta_{F,X} = 1 \; \forall \; i \tag{3}$$

where *F = {Nearshore, Offshore}*, and $X_{F,t}$ is the stock size of fish *F* at time *t*. Following Gilliland et al. (2016), we assume that the fish stocks may be considered fixed at time *t*, and update between periods given the levels of harvest and stock size at time *t*.

Demand for factor inputs of fishing production are determined within each period, assuming fish stock is fixed, such that the economy balances. Because households operate in an open access fishery, we assume that fishermen are not forward-looking, and are not basing production decisions in time *t* on future fish stock or fishing sector profitability. The open access nature of fishery stocks suggest that factors of production will be overallocated, driving economic profits in the sector to zero. Following methodology described by Manning et al. (2016), we assume that each factor input in fishing production takes a proportion of the share of value-added attributable to the stock, denoted $\theta_{F,f}$, based on each factor's relative contribution of the value-added such that $\theta_f = \frac{\beta_{F,f}}{\Sigma_f \beta_{F,f}}$. Therefore, the factor input demands for fishing production are given by,

$$FD_{F,f,t} = \frac{Y_{F,t} PVA_{F,t} (\beta_{F,f} + \theta_f \beta_{F,X})}{w_{f,t}} \tag{4}$$

When $\beta_{F,X} > 0$, indicating that fish stock is an important determinant of production, factor demand will be greater than equation 2.

Based on Selayar's economy, we model the local labor supply as fixed, in that there is no migration into or out of the economy. For instance, while there is a daily ferry from the province's main island to Selayar Island, and travel in and out of ports is possible via private boats, high transportation costs would reasonably limit labor flowing into or out of the island economy. Labor within the economy can move between different production activities. Family labor and hired labor are assumed to be perfect substitutes for one another. Additionally, because Selayar is small island, with relatively steep terrain, agricultural land is assumed to be fixed.

Currently, the amount of capital in each economic activity is assumed to be fixed. As discussed previously, households own a stock of fishing capital which they are able to allocate between nearshore and offshore fishing activities.

Finally, household consumption demands are assumed to follow linear expenditure systems without minimum consumption constraints. Thus, households spend a fixed share on income on each of the six good categories: agriculture and livestock, nearshore fish, offshore fish, retail goods, restaurants, and other services.

Bioeconomic Model:

Using data to estimate harvest, and assuming fish stock growth rate and that the initial stock size is a faction of carrying capacity, we are able to derive carrying capacity such that the system is at bioeconomic equilibrium at baseline. For each policy simulation, we assume that the nearshore fish stock is at steady state at baseline (t=0), such that stock growth is equal to harvest.

Policy Simulations:

The government has expressed interest in giving poor small-scale fishermen 5 GT fishing boats. According preexisting national regulations, boats that are 5 GT or larger may not fish within 4 nm of the shore. However, the difficult task of monitoring and enforcement of this regulation is delegated to local governments. Local capacity for enforcing boat regulations is often limited, and permits indicating boat size can be easily forged.

While the provisioned boats are intended to encourage fishermen to engage in offshore fishing activities, depending on local enforcement capacity, these boats could be used for either fishing activity. For this reason, we consider scenarios in which offshore fishing capital is restricted to offshore fishing production, and another in which fishing capital may be costlessly reallocated between the two fishing activities.

We simulate the boat provisioning policy by increasing the representative poor fishing households' offshore fishing capital endowment by 75%. We assume that this increase in fishing capital is maintained for the entire simulation period (10 year). This marine policy is simulated under two plausible scenarios. In the first scenario, fishing capital is non-malleable: offshore fishing capital can only be used for offshore fishing, and nearshore fishing capital can only be used for nearshore fishing. This scenario approximates a situation in which boat regulations are fully enforced. In the second scenario, we relax this assumption, allowing fishing capital to be malleable: fishing capital can be costlessly reallocated between activities. This approximates a situation in which boat regulations are not fully enforced.

Data

The Bio-LEWIE model is parameterized using a unique data set collected in September - October 2016. Data collection was carried out by the lead author and a team of researchers from a local university Univerisitas Hasanuddin. Surveys were administered and data was collected for a total of 256 businesses and 487 households. Business surveys were randomly selected from a list of all registered businesses in the urban subdistrict Benteng, location of the district capital and main port. Household surveys were administered in 12 of the 52 villages on Selayar Island.

Villages were selected using a stratified random sampling technique. From each selected village, two subvillages were randomly selected such that the probability of selection was proportional to its population relative to other subvillages. Typically, each village contain 3-5 subvillages, containing roughly 25 – 200 households each. The survey team worked with subvillage leaders to assemble household rosters from which a random sample of households was generated. The number of households selected from each subvillage was proportional to its population size.

Business surveys gathered information detailing business' use of hired labor, expenses, sales and financing. When applicable, information on the use of fish inputs was collected. Household surveys collected data on household demographics, production (fishing, agriculture, livestock, enterprise), purchase, food security, and finance. If households engaged in fishing activities, detailed information was collected on fishing behavior and harvests. Fishing households were asked to describe different types of fishing activities, or fishing trips, they carried out in the past year. Unique fishing activities may be distinguished based on season, habitat or location visited, gear used, fish targeted. On average, fishing households described between 2 and 3 fishing activities. Details on location, gear used, number of fishermen, and harvest were gathered for each fishing trip.

All production activities, assumed to follow Cobb-Douglas technology, are characterized by share value added of factor inputs ($\beta_{i,f}$) and a shift parameter (A_i) where *i* indicates sector, and *f* indicators factor input. Parameters for all activities are estimated such that

$$\ln(Value\ Added_i) = \widehat{A_\iota} + \Sigma_f [\, \widehat{\beta_{\iota,f}} \ln\big(Value\ Services_f\big)].$$

Fishing production is assumed to depend on two factors inputs: labor and fish capital. For estimation, labor is represented by the total person hours spent fishing during a fishing trip, and capital is represented by the total value of capital services spent during a fishing trip.

As discussed previously, we have chosen to model offshore and nearshore fishing as two separate production activities. Offshore fishing activities, occurring entirely or primarily in pelagic habitat, lead to the harvest of primarily tunas, mackerel, jacks and trevallies. Nearshore fishing, occurring entirely or primarily in sea grass, coral reef and mangrove habitat, leads to the harvest of different fish families, including groupers, snappers, emperors, parrotfish, rabbitfish, triggerfish. Formally, a fishing trip was classified as an offshore fishing trip if 50% or more of the fishing time was spent in pelagic habitat. Trips in which 50% or more of the fishing time was spent in coral reef, sea grass or mangrove were designated as nearshore fishing trips.

Of the 487 households surveyed, 152 households were categorized as fishing households. A total of 347 different of fishing trips were described, 51 of which were offshore fishing trips. Fishermen reported using a variety of boats for both offshore and nearshore fishing activities. While most of the nearshore fishing trips used smaller, traditional fishing boats, some nearshore fishing trips included boats that are similar to the 5 GT boats discussed previously. Additionally, many offshore fishing trips employed traditional fishing boats, indicating that a large boat is not necessary for fishermen to engage in offshore fishing activities.

Despite potential overlap in boats used, we believe offshore and nearshore production are sufficiently different to warrant definition of two distinct production activities. Offshore fishing involves distinctly different gear types and fishing strategies, as well as a different composition of harvest. The fishing production parameters, summarized in Table 1, were estimated using village random effects on pooled fishing trip data. Using an offshore dummy variable and interacting the offshore indicator with value of capital added and labor, we find evidence that nearshore fishing and offshore fishing are best characterized by distinct production parameters. The results of the joint hypothesis test are displayed in Table 2. The resulting fishing production parameters, summarized in Table 3, confirms our prior intuition: nearshore fishing is a relatively labor-intensive activity, while offshore fishing is a relatively capital-intensive activity.

Results

The parameterized and calibrated Bio-LEWIE has been used to simulate marine stimulus policies under two plausible regulatory scenarios. A boat provisioning policy has been simulated by increasing the representative poor fishing households' offshore fishing capital endowment by 75%. The increase in fishing capital is maintained for the entire simulation period (10 year).

Scenario 1: Non-Malleable Fishing Capital

In the first simulation, fishing capital is assumed to be non-malleable: offshore fishing capital can only be used for offshore fishing, and nearshore fishing capital can only be used for nearshore fishing. Therefore, the boat subsidy given to poor fishing households may only be used for offshore fishing activities. Neither new nor existing fishing capital can be reallocated.

The projected effects on the four representative household groups' real income are illustrated in Figure 1. The real income of the target household, the poor fishing household, increases considerably after receiving the offshore fishing capital. In Figure 2, we take a closer look to see the effects the marine stimulus policy has on non-target households. Non-target household groups indirectly benefit from marine stimulus policy when poor fishing household increase demand for produced goods and services. The poor non-fishing household experiences a small increase in real-income, just over 1.25%. Though the increase declines with time, this representative household maintains an increase in real income over the 10-year time horizon. Both the non-poor fishing household and the non-poor non-fishing household see a slight increase in real income at the beginning of the time horizon, but the benefits dissipate over time. By the end of the 10-year time horizon, both household groups are worse off, relative to the pre-policy baseline.

Dissipation of increases to real income are, in part, attributable to increasing price of nearshore fish. In Figure 3, we see the nearshore shock declines a modest amount over the entire simulation period. Immediately following policy implementation, the price of nearshore increases 0.49%, the result of increased demand from the poor fishing household group. As nearshore fish stock declines, the local price continues to increase.

Higher output price means fishing households receive increased returns to labor, incentivizing households to increase labor allocated to nearshore fishing. In aggregate, the households of Selayar increase total labor allocated to nearshore fishing in the first five years following implementation of the marine stimulus policy (as seen in Figure 4). However, returns to fishing capital and labor also depend on stock size. As the nearshore fish stock decreases, returns to fishing capital and labor decrease. A positive search cost further increases the cost of fishing when the fish stock declines. Eventually, returns to labor are too low, households allocate less labor to nearshore fishing. Less labor, relative to the pre-policy baseline, is allocated to nearshore fishing by the end of the 10-year time horizon.

Scenario 2: Malleable Fishing Capital

In the second simulation, fishing capital is assumed to be malleable: fishing capital can be costlessly reallocated between activities. Therefore, new and existing fishing capital can be reallocated between the two fishing activities.

The four representative households experience similar changes in real income as discussed previously, illustrated in Figure 5 and 6. However, now we see a more rapid decline in real income over the simulation period. When fishing capital is malleable, some of capital given to poor fishing households is being reallocated to nearshore fishing. As a result, the nearshore fish stock will decline faster (Figure 7). Households increase more labor and fishing capital to nearshore fishing in response to higher local price. Because the stock declines faster, labor in the nearshore fishing begins to decrease, relative to baseline, after just two years.

Conclusion

Government sponsored distribution of boats is thought to be a non-regulator way to encourage poor fishing households to out of vulnerable nearshore fisheries and into offshore fisheries. Not only is there an interest in increasing offshore fish production, this type of marine policy is implemented with hopes of alleviating poverty and promoting conservation. The results of the policy simulations suggest this marine stimulus may have mixed success in a rural coastal economy.

The policy definitively helps the target households receiving the boat subsidy. An increase in poor fishing household's real income is sustained throughout the simulation period. However, some household groups will be worse off after the policy is implemented. In both regulatory scenarios, the boat provisioning policy led to increased offshore fishing and, eventually, decreased nearshore fishing in the economy. However, the decrease in nearshore fishing comes at the expense of the nearshore fish stock. Immediately following policy implementation, households increases labor allocated to nearshore fishing. As nearshore fish stock declines, less time is spent in the nearshore fishery. When fishing capital is malleable, the nearshore fish stock is driven down faster.

This study offers new perspectives on the biological and local economy impacts of a common marine policy implemented in rural coastal communities in developing countries. The steps taken to characterize fishing production and capital allow us to realistically depict household behavior. Grounding our model using a unique microeconomic dataset, we simulate the impacts to a local economy in Eastern Indonesia, demonstrating to what extent short-term support for small-scale producers can achieve poverty alleviation and conservation objectives. Estimates of local economy-wide effects can help us re-examine blue policy initiatives being employed in developing countries around the world.

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Table 1: Fishing production parameter estimates

	Coef.	Std. Err.
Offshore*ln(Labor)	-0.3768	0.265
Offshore*ln(Capital)	0.4625***	0.163
Offshore	-0.3889	0.501
ln(Labor)	0.4981***	0.060
ln(Capital)	0.2324***	0.046
Constant	3.7088***	0.127

*** = 1% significance

Estimates generated using pooled random effects estimation, clustered by village. Offshore is a dummy variable equal to 1 for offshore fishing trips, 0 else.

Table 2: Joint hypothesis tests of offshore parameter estimates

test: _b[Offshore*ln(Labor)] = _b[Offshore*ln(Capital)] = _b[Offshore]

(1) **_b[Offshore*ln(Labor)] - _b[Offshore*ln(Labor)] = 0**

(2) **_b[Offshore*ln(Labor)] - _b[Offshore] = 0**

(3) **_b[Offshore*ln(Labor)] = 0**

chi2 (3) = **21.65**

Prob > chi2 = **0.0001**

Table 3: Offshore and nearshore production parameter estimates

	Offshore	Nearshore
Labor	0.1213	0.4981***
	(0.257)	(0.060)
Capital	0.6949***	0.2324***
	(0.157)	(0.046)
Shift	3.3199***	3.7088***
	(0.493)	(0.127)

*** = 1% significance

Figure 1: Percentage Change in Real Incomes – All Household Groups

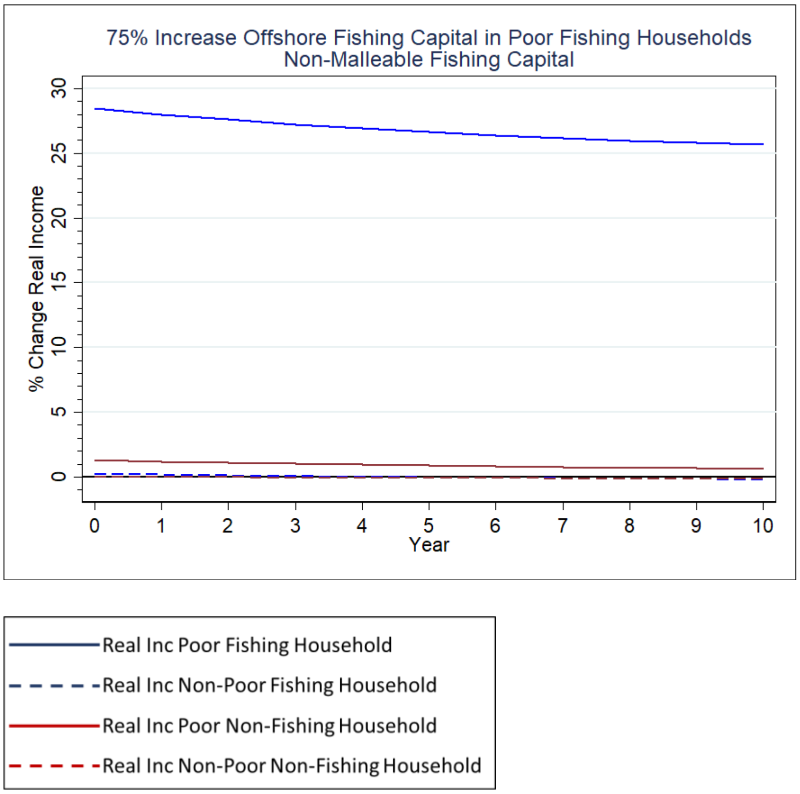

Figure 2: Percentage Change in Real Incomes – Non-Target Groups

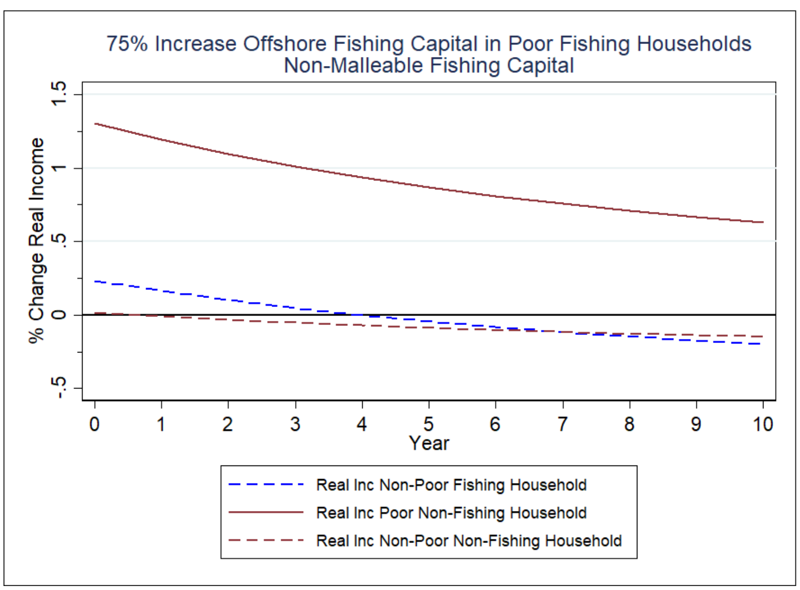

Figure 3: Percentage Change in Nearshore Fish Stock

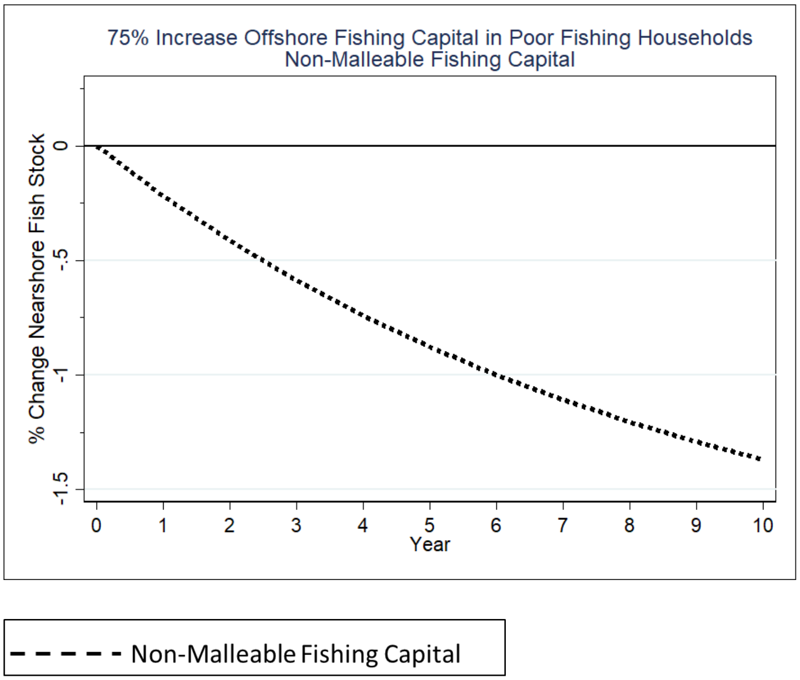

Figure 4: Percentage Change in Labor Allocated to Fishing

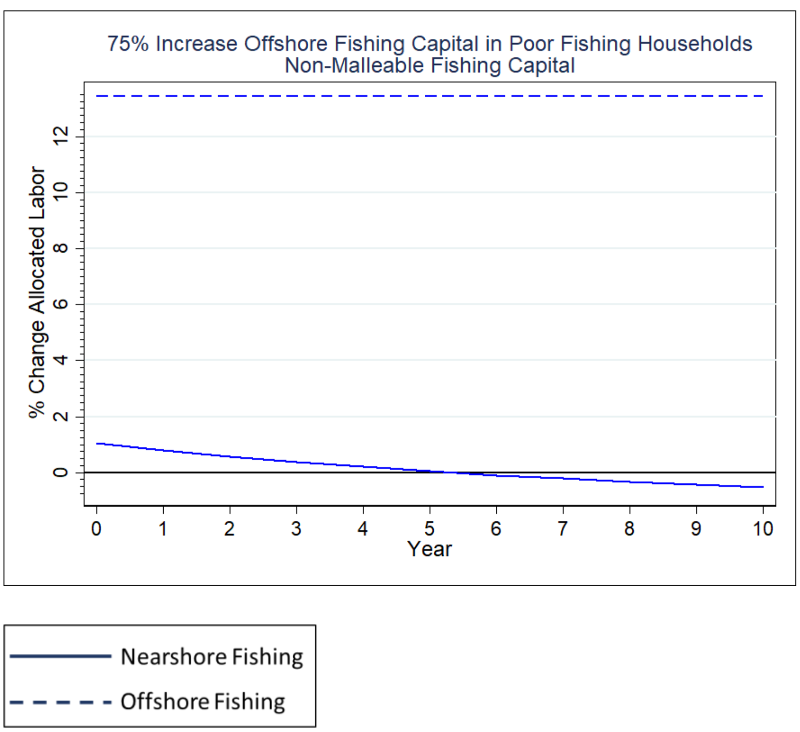

Figure 5: Percentage Change in Real Incomes – All Household Groups

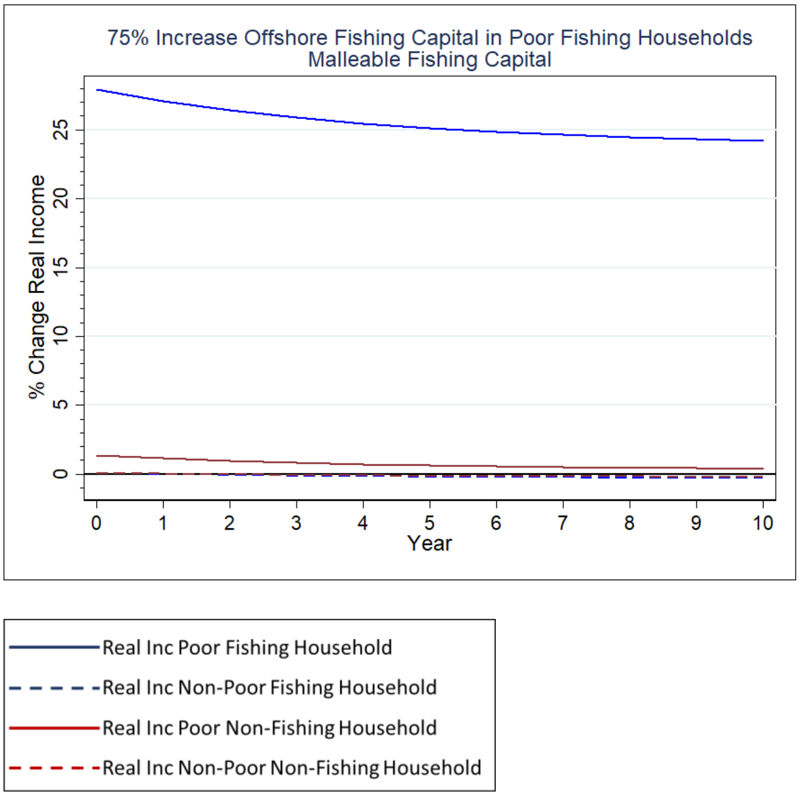

Figure 6: Percentage Change in Real Incomes – Non-Target Groups

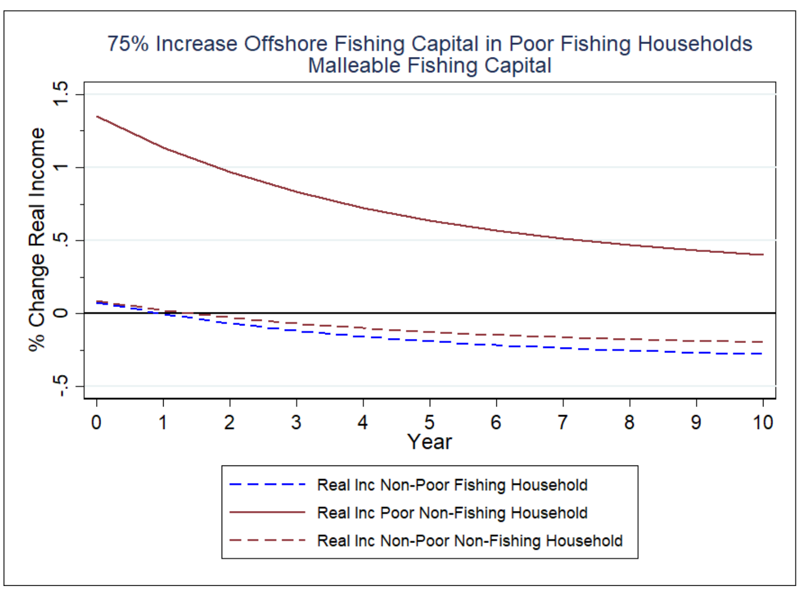

Figure 7: Percentage Change in Nearshore Fish Stock – Malleable Fishing Capital

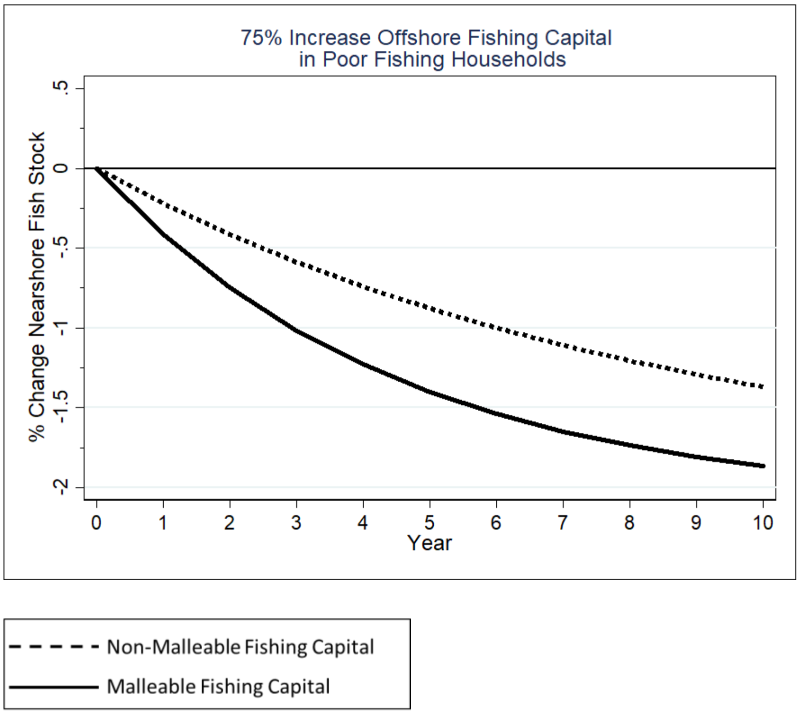

Figure 8: Percentage Change in Labor Allocated to Fishing