FISHING AND NON-FISHING INCOME DECISIONS: THE ROLE OF HUMAN CAPITAL AND FAMILY STRUCTURE

Shaikh M.S.U. Eskander [a,♣], Edward B. Barbier [b], Benjamin Gilbert [b]

[a] Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK

[b] Department of Economics and Finance, University of Wyoming, 1000 E. University Avenue, Laramie, WY 82071, USA

Forthcoming in Land Economics, volume 94, issue 1, February 2018

Acknowledgments:

Several institutions collaborated to design and implement the Malaysian fishing household survey and we are grateful to them for making the data available for this analysis: the Malaysian Department of Fisheries, the Turtle and Marine Ecosystem Centre, World Wildlife Fund-Malaysia, the National Oceanic and Atmospheric Administration-Fisheries, the Department of Economics at UC San Diego, The WorldFish Center, and in particular Ted Groves, Dale Squires, and Bee Hong Yeo. We thank Thorsten Janus, Ben Rashford and Alexandre Skiba for helpful comments on the analysis. Eskander acknowledges the financial support of the Grantham Foundation for the Protection of the Environment, and the ESRC Centre for Climate Change Economics and Policy. All errors are our own.

♣ Corresponding author. Tel: +44(0)78 5600 3276 | E-mail: S.M.Eskander@lse.ac.uk | Fax: +44(0)20 72420392.

FISHING AND NON-FISHING INCOME DECISIONS: THE ROLE OF HUMAN CAPITAL AND FAMILY STRUCTURE

Resource-dependent households often diversify their income. We model demand for remittances and supply of off-resource labor as a joint decision, and discuss household tradeoffs. We extend the off-farm labor supply literature to a rural fishery, contrasting our results to common findings in the farm literature and providing empirical evidence of the interdependence between education and family structure in determining income diversification. Using a unique dataset from Malaysia, we find that more educated households are less likely to diversify their income, with caveats depending on family composition. Policy implications for resource management in a remittance economy with alternative livelihoods are discussed.

JEL Codes: Q22, J24

I. INTRODUCTION

Resource-dependent households often diversify their income sources in response to resource scarcity and changing economic conditions. They may allocate labor to wage employment in local industries or receive financial support from working-age children, such as remittances from those living away from home or contributions from adult children living at home. A large literature dating back to Huffman (1980) has studied the determinants of off-farm labor supply among farming households, particularly with respect to the importance of human capital and family composition. This literature often treats financial support from family members as an exogenous source of income rather than as part of the household's decision process; yet there is a tradeoff in allocating time between leisure and labor versus seeking financial support in order to finance consumption. However, since intra-household labor allocation between resource-dependent sectors and remittance-earning outside sectors is a joint decision made by the household and not by individual members (Abdulai and Delgado

1999), labor supply decisions of the migrant or non-migrant extended family members who provide financial supports are incorporated in the household's integrated labor allocation decisions; whereas the consequent intra-family flow of remittances are included in household's utility maximization problem.

While such migration takes place for various reasons, new economics of labor migration (NELM) argues that relative deprivation within a community can force households or individuals to migrate (Stark and Bloom 1985); whereas such deprivations can be triggered among the rural people, who have predominant dependence on natural-resource based livelihood mechanisms such as agriculture, fishing and forest-based activities. There may be opportunity costs to the household of the family member's time, pecuniary and non-pecuniary transactions costs associated with sending and receiving funds, and disutility associated with requesting funds and/or sending a family member away to work. Starting from Lucas and Stark (1985), a related strand of literature has studied the determinants of remittance supply from migrated family members and the consequent macroeconomic impacts (e.g., Rapoport and Docquier 2006; Yang 2011; Brown and Jimenez-Soto 2014; Funkhouser 1995; McCormick and Wahba 2000). Especially the households living in marginal or frontier environment use natural resource extraction as insurance to smooth total income against income and livelihood risks (Takasaki, Barham, and Coomes 2010; Takasaki, Barham, and Coomes 2004; De Sherbinin *et al.* 2008; Takasaki 2011).[1] We argue that because both remittances and off-resource labor supply can be used to supplement resource-dependent incomes, they may share common determinants at the household level of the recipient. That is, the determinants of labor/leisure allocation decisions may also determine the demand for intra-family financial support. However, this has not been thoroughly investigated in the context of resource dependence and resource management, especially in the case of fisheries.[2]

In this article we investigate, in the tradition of Huffman (1980), the role of human capital and family structure in the joint determination of demands for financial support and non-fishery labor incomes for rural fishery-dependent households in Malaysia. In doing so, we review and combine three related strands of literature on off-resource labor supply, intra-family financial support, and natural resource management. First, the off-farm labor supply literature commonly treats intra-household financial support as an exogenous control variable, and generally finds that human capital has important influences on off-farm employment. Rural households with higher human capital tend to look for off-farm wage employment or otherwise switch from farm to off-farm activities (e.g., Huffman 1980; Huffman and Lange 1989; Fafchamps and Quisumbing 1999; Holden, Shiferaw, and Pender 2004; Yang 1997a; Taylor and Yunez-Naude 2000). Further, the lack of appropriate human capital can act as a barrier to non-farm employment (Abdulai and CroleRees 2001; Escobal 2001; Barrett, Reardon, and Webb 2001; Barrett *et al.* 2005). Education seems to have a greater impact on off-farm work opportunities than on the marginal product of farm labor, although an educated worker may generate knowledge spillovers onto farm productivity even while participating in off-farm work (Yang 1997a; Yang 1997b; Asadullah and Rahman 2009). In contrast, we find that educated households are generally *less* likely to earn non-fishery labor income *or* receive remittances, with some exceptions related to family structure. The fisheries literature in general has conflicting findings about the relationship between education and fishing productivity.[3] In our empirical setting we find no evidence of education being associated with a shift in the marginal product of fishing labor, and we discuss alternative channels through which education may be related to off-fishery labor supply and remittance demand.

Second, human capital and family structure are among the microeconomic determinants of the urban-to-rural and international flow of remittances (e.g., Lucas and Stark 1985; Rapoport and Docquier 2006; Yang 2011; Brown and Jimenez-Soto 2014; Funkhouser 1995).[4] Much of this literature focuses on the migrant's decision to remit, or on macroeconomic issues such as brain-drain, migrant labor allocation and real exchange rates (Rapoport and Docquier 2006),[5] and not on natural resources management as we know of. Papers investigating the interplay between remittance receipts and alternative local labor employment do not generally consider them as simultaneously determined sources of supplementary income. For example, Yang (2008) considers remittances as insurance against income vulnerability in a decaying resource stock industry, and his results imply a positive relationship between remittances and non-resource-based incomes. In contrast, we observe very few fishing households in our setting with both remittance income and non-fishing labor income. Another strand of this literature investigates the causal effect of remittance receipts on labor supply and finds that the effect can be positive or negative depending on family structure and human capital (e.g., Amuedo-Dorantes and Pozo 2006; Grigorian and Melkonyan 2011); the net effect on household labor supply may depend on whether the lost income from out-migrating children is replaced by new remittance income – and this in turn can depend on human capital levels. Our study complements and extends this literature by jointly estimating the human capital and family structure determinants of off-resource labor earnings and receipts of financial support, rather than the causal effect of remittances on labor, treating the demands for financial support and non-fishery incomes as a joint decision.

Third, the literature on resource management with respect to off-resource labor supply primarily explores the relationship between resource dependence and labor allocation again assuming intra-family financial support is exogenous to resource exploitation and labor supply (e.g., Barbier 2007; Barbier 2010). For example, Barbier (2007) considers exogenous remittances when studying the labor allocation decisions of mangrove-dependent rural households, whereas Barbier (2010) focuses on the impact of resource abundance on labor allocation to explore implications for poverty traps and resource degradation. We provide a detailed discussion of the implications of our theoretical model and empirical results for resource management.

This is the first such investigation for fishing households that we know of. Many rural fishing households lack formal or well-functioning credit and insurance markets (e.g., Abdulai and CroleRees 2001; Barbier 2010), so supplementary income sources are important for the household's well-being. Although global fish production has exceeded population growth over the past several decades, the vast majority of this growth has come from aquaculture while production from marine capture fisheries has declined due to resource stock degradation, and employment in capture fisheries has declined even more dramatically (FAO 2014). This poses a global conservation and development problem when it comes to supporting livelihoods and conserving or rebuilding stocks. Traditionally, fishing was thought of as an occupation of last resort in which fishers are among the poorest people who may switch their occupation with minimal incentives, but a more recent literature has shown that some fishers enjoy their occupation and are reluctant to permanently change livelihoods even with potentially drastic resource stock declines (e.g., Pollnac, Pomeroy, and Harkes 2001; Cinner, Daw, and McClanahan 2009; Muallil *et al.* 2011; Daw *et al.* 2012; Slater, Napigkit, and Stead 2013; Reddy, Groves, and Nagavarapu 2014).

For empirical investigation, we use a uniquely detailed survey dataset of individual fishing captains from the east coast of Peninsular Malaysia which separately measures the households' receipts of financial support from working-age children who live in the home versus outside the home – an important detail not present in many rural household surveys that gather information about remittances – in addition to fishing revenue and non-fishery labor income. Using a series of lognormal hurdle (LH) models for non-fishery labor income and financial support,[6] we find that human capital (i.e., schooling status of the household head) and family size influence the demands for financial support (i.e., receipts of contributions from live-in children and remittances from live-away children) and non-fishery incomes. More educated households are less likely to earn non-fishing labor income or receive intra-family financial support, unless they have large families. In general, larger families are more likely to receive intra-family transfers and less likely to have non-fishery labor incomes. We discuss the implications for fisheries management of policies that reduce remittance transactions costs or develop non-fishing employment sectors as alternatives to standard policies that attempt to limit or otherwise regulate fishing inputs.

II. AN ANALYTICAL MODEL OF RURAL FISHING HOUSEHOLDS

Consider a representative fishery-dependent household that maximizes utility subject to time, income, and fishing harvest constraints. The household's primary income source is the market sale of harvested fish, but members may also participate in non-fishing wage employment and may seek financial support from working-age children. For simplicity, we assume that working-age family members' labor is homogeneous and the household makes joint allocation decisions over the total labor endowment L, which potentially includes allocating members' time to distant labor markets for the purpose of sending remittances back home.[7] The household head runs the fishing operation, including operating the fishing boat as its captain and managing production, sales, etc, and therefore the labor allocated to fishing is always positive. In our empirical setting, the household head is also the fishing captain and the head of the fishing business, so we will use these terms interchangeably.

Household utility is assumed to be determined by a market-purchased composite consumption good x, the amount of labor allocated to remittance-earning activities l^R, and leisure l^u, broadly defined to include production and consumption of nonmarket goods within the household (Barnum and Squire 1979). Note that the representative household makes a joint decision for all its working-age members about the allocation of labor between fishing and non-fishing activities in the same locality as well as remittance-earning activities outside the locality. The demand for financial support is met through household's choice of l^R at an increasing and convex cost to household utility. The disutility of remittances can arise from worry over the migrant family member's well-being, or from shame or reduction in status from requesting financial support.[8] If the household actively selects a family member to out-migrate for the purpose of remitting, they may experience both sources of disutility as well as an opportunity cost of foregone labor in the fishing operation and in home production. It is also possible that family members migrate for personal reasons rather than as part of a joint household decision, but the household may subsequently request financial support. In this case, the household may still experience the second source of disutility, and we can think of l^R as a monetary request that does not enter the household's labor endowment. Our empirical evidence is consistent with both a direct disutility of remittance requests and an indirect opportunity cost to the household, so we allow for both channels in the model.[9, 10] The household maximizes

$$U(x, l^u, l^R; \psi, h) = u(x, l^u; \psi, h) - v(l^R; \psi, h), \qquad [1]$$

where h is the level of human capital attained by the household head, and ψ is a vector of household characteristics, such as the age of the household head and family size.[11] We assume that u is strictly concave and twice continuously differentiable in its arguments: $u_x, u_{l^u} > 0, u_{xx}, u_{l^u l^u} < 0$; whereas v is strictly convex and twice continuously differentiable, $v_R > 0, v_{RR} > 0$, so that the overall utility function U is well-behaved.

The marginal utility of consumption and leisure, and the marginal disutility of requesting financial support, in general depend on both family composition and human capital attained. For example, the marginal utility of consumption and leisure (or home production) may depend on the number of school-aged children supported within the home, and the satisfaction of supporting their education may depend on the education level of the household head. To the extent that there are educational spillovers from parent to child, however, educated households may produce children with greater income-earning potential, which could reduce the marginal disutility of requesting financial support. We will return to this discussion in the analysis of the model.

The household harvests fish according to the concave and twice continuously differentiable production technology:

$$y = f(l; N, c, \psi, h), \quad f_l > 0, f_{ll} < 0, \qquad [2]$$

where l denotes household labor employed in fishing activities, N represents characteristics of the fishery such as resource stocks and regulatory structures that are exogenous to and common across individual fishing households, and c is a composite predetermined fixed input such as the type of boat available to the household.[12] We allow for the possibility that family size affects fishing productivity, such as the number of working-age children available to assist with fishing operations. Because the household head is also the fishing captain and business manager, age and human capital attainment can also affect fishing productivity.

The household allocates its labor endowment between fishing, local wage employment, leisure or home production, and distant labor markets according to:

$$L = l + l^w + l^u + l^R, \quad l > 0, l^u > 0, l^w \geq 0, l^R \geq 0. \qquad [3]$$

We assume positive fishing labor, $l > 0$, because fishing is the primary occupation of the household. The household may also supply $l^w \geq 0$ for paid employment at the local market wage rate w to earn non-fishing income wl^w. While we treat wages as exogenous, wage rates may differ with more educated household heads able to attain higher-paying non-fishing employment so that $w = w(h)$, $w_h > 0$.[13] Since h is predetermined in a static framework, and is not a choice variable, and we continue using the notation w instead of $w(h)$.

We normalize the price of x to unity and let p denote the market price of fish. The household earns $py + wl^w$ from fishing and non-fishing employment, spends x on consumption, and may receive financial support αl^R. Here α is the fraction of the family member's income received by the household, summarizing wages in the distant labor market and transactions costs of financial transfers. Plugging [2] in for fish harvest, equation [4] expresses the income constraint as:

$$x = pf(l; N, c, \psi, h) + wl^w + \alpha l^R, \quad x > 0, f(l; N, c, \psi, h) > 0, l^R \geq 0. \quad [4]$$

The household maximizes equation [1] subject to [3], [4] and the inequality constraints $l^w \geq 0 \; and \; l^R \geq 0$:

$$\max_{x,l^u,l^R,l^w,l} u(x, l^u; \psi, h) - v(l^R; \psi, h) - \lambda[x - pf(l; N, c, \psi, h) - wl^w - \alpha l^R]$$
$$- \mu(l + l^w + l^u + l^R - L) - \gamma_w l^w - \gamma_R l^R, \quad \gamma_w l^w = 0, \gamma_R l^R = 0,$$

where γ_w, γ_R are the shadow values of the inequality constraints and λ, μ are the shadow values of the income and time constraints, respectively. The first-order conditions for an interior optimum ($\gamma_w = \gamma_R = 0$) are given by [3], [4], and:

$$\begin{aligned} u_x &= \lambda \\ u_{l^u} &= \mu \\ v_R &= \alpha\lambda - \mu \\ w\lambda &= \mu \\ \lambda p f_l &= \mu. \end{aligned}$$

Together these imply that $w = \frac{u_{l^u}}{u_x} = pf_l = \alpha - \frac{v_R}{u_x}$, or that when nonzero amounts of household labor are optimally allocated to all activities, this allocation equates the marginal value of time across activities: the local non-fishing labor wage, the marginal rate of substitution between leisure and consumption, the marginal value product of fishing labor, and the remittance rate less the relative disutility of requesting financial support from family members. One implication of this is that the distant labor market must pay a premium in order to induce migration, which covers the marginal rate of substitution between household consumption and the disutility of requesting support. This can be seen by solving the marginal condition for $\alpha = \frac{v_R + u_{l^u}}{u_x} = \frac{v_R}{u_x} + pf_l = \frac{v_R}{u_x} + w$.

The conditions for a more general solution in which l^W and/or l^R may be at a corner solution are summarized by:

$$w \leq u_{l^u}/u_x = pf_l \qquad and \qquad \alpha \leq \frac{v_R + u_{l^u}}{u_x}. \tag{5}$$

That is, the marginal value product of fishing labor and the marginal rate of substitution between consumption and leisure or home production are always equated at the optimum, which is consistent with the NELM literature. For example, Stark (1991) hypothesized that migrant's remittances enable rural households to overcome credit and risk constraints related to their production decisions. Consistent with this, we assume that migration of members is a joint decision made by the household. However, we do not explicitly model the migration decision since our dataset does not contain detailed information on migrant household members. Although migrants might be a non-random sub-sample of the rural population (Hoddinott 1994), the process that determines out-migration may be unrelated to labor supply decisions (Dustmann and Görlach 2016b). Especially since many migrations are temporary (Dustmann and Görlach 2016a), and since we only focus on labor allocation decisions, we do not model migration explicitly, rather we use proxies such as education and levels of income from fishing which characterize the household decision to send a migrant (Haberfeld *et al.* 1999).

However, our model indirectly captures the increased income of the migrant household members relative to the origin. Consistent with Rozelle, Taylor, and deBrauw (1999), remittances received from migrant family members may have positive or negative effects on local non-fishing income: positive effects if they are complements, and negative effects if they are substitutes. Furthermore, we observe in our data that almost all households are at a corner solution for either l^w or l^R. Therefore, corner solutions, $l^{w^*} \geq 0$ and $l^{R^*} \geq 0$, to our optimization problem are important. If the marginal value of time in fishing and leisure exceeds the marginal value of time in the local labor market, no labor will be supplied for local wage employment. Likewise, if the marginal rate of substitution between consumption and combined remittance opportunity costs exceeds the remittance rate α, no financial support will be requested. The combined remittance opportunity cost includes the direct disutility of requesting financial support and/or sending away a migrant, and the household opportunity cost of the migrant's labor.

If there is no disutility from remittances, then we have:

$$w \leq u_{l^u}/u_x = pf_l \qquad and \qquad \alpha \leq u_{l^u}/u_x = pf_l \,, \tag{5'}$$

in which case local non-fishing labor income and remittances are perfect substitutes and households choose the most remunerative non-fishing income opportunity, or none at all.

If, on the other hand, a family member makes a private decision to migrate which is independent of the household's joint decision and labor endowment, and the household experiences disutility from requesting financial support from that person, then we have:

$$w \leq u_{l^u}/u_x = pf_l \;\; and \;\; u_x \leq v_R \quad \Longrightarrow \quad u_{l^u}/v_R \leq u_{l^u}/u_x = pf_l, \tag{5''}$$

determining the optimal labor allocation and financial support demand, and households may choose either, both, or neither sources of supplementary income. This scenario is depicted in Figure 1.

We will focus on the model with [5] because it captures the special cases of [5'] and [5'']. Let $\bar{w} \equiv [u_{l^u}/u_x = pf_l]$ define the reservation wage at which the household does not supply labor for outside employment, and $\bar{\alpha} \equiv \left.\frac{v_R + u_{l^u}}{u_x}\right|_{l^R=0}$ define the reservation remittance rate at which the household does not supply labor to distant markets. The household's non-fishing labor supply and financial support demand functions are therefore given by:

$$l^{w*}(\Lambda) = \begin{cases} l^{w**}(\Lambda) & if\ w \geq \bar{w} \\ 0 & if\ w < \bar{w} \end{cases} \quad and \quad l^{R^*}(\Lambda) = \begin{cases} l^{R^{**}}(\Lambda) & if\ \alpha \geq \bar{\alpha} \\ 0 & if\ \alpha < \bar{\alpha} \end{cases}, \qquad [6]$$

where $\Lambda = \{\psi, h, N, c, p, w\}$. Both the functions, $l^{w*}(\Lambda)$ and $l^{R^*}(\Lambda)$, are censored at zero, which would be the optimal choices $l^{w**}(\Lambda)$ and $l^{R^{**}}(\Lambda)$ absent non-negativity constraints. Optimal decisions fall into one of four cases: a corner solution for local labor supply and financial support demand, an interior solution for both, and a corner solution for one of the supplemental income sources with an interior solution for the other. Although each of these cases is technically possible, an interior solution for both may be less likely because of the opportunity cost of the household labor; increasing one supplemental income source generally implies a reduction in the other. These tradeoffs are illustrated in Figure 2.

The comparative statics of l^{w*} and l^{R^*} cannot be signed in general because of the potential for human capital attainment and family characteristics to interact as they affect multiple sources of income and utility. To see this, consider Figure 2. At the initial remittance rate α and wage w, there is an interior solution for both sources of supplementary income. An increase in education could raise α to α' as shown in Panel A by improving the income-earning opportunities in a distant urban labor market. Some family members are then more likely to migrate, increasing the marginal utility of leisure and home production and reducing the time allocated to local labor markets and/or fishing. Note that we would also observe an increase in α when distant labor markets are booming, or if there are fewer transactions costs, such as lower banking and transfer fees or more money transfer institutions in proximity to the rural household. Education could also make the household eligible for better local employment, raising the wage from w to w' as in Panel B and increasing the household's supply of local wage labor, but also raising the marginal utility of leisure and shifting in the supply of labor to the distant market. Local alternative livelihoods programs could have a similar impact on w, drawing labor out of the fishery but also potentially out of leisure as well as reducing out-migration. These competing effects are further complicated by the potential for human capital to change the marginal productivity of home production, which here is captured by the marginal utility of leisure. This would shift up the labor supply curve for both local and distant markets, reducing the likelihood of any income diversification. Likewise, education could improve the productivity of fishing, shifting out the fishing labor demand curve (pf_l). This directly reduces the local wage labor supply, and eventually increases the marginal utility of leisure, which also reduces remittances. The net effect of an increase in human capital on labor allocation therefore depends on the relative impacts on marginal utilities, marginal fishing productivity, and outside opportunities.

The effect of family characteristics is similarly ambiguous. Consider, for example, the effect of an increase in the number of working-age children living outside the home. How this impacts the marginal disutility of requesting financial support (v_R) depends on the employment success of these children. Raising more children may leave fewer resources available for the education of each child, making the children less able to provide financial support in adulthood. This could increase the household's marginal disutility of requesting financial support and shift in the supply of labor to remittance-earning activities. If the household head is well-educated, and education spills over to the children, then the opposite may be true – having more adult children may decrease v_R, increasing the likelihood of positive financial support. However, while an increase in education may have an indirect positive effect on v_R as described, it may also have a direct negative effect if requesting financial support is more shameful for a more educated household head.

As the goal of this paper is to provide econometric evidence for which of these competing effects is empirically important in determining the composition of income sources, we turn now to the details of the empirical approach.[14]

III. EMPIRICAL APPROACH AND DATA

Empirical strategy

The conceptual model shows that the optimal decisions of supplementary income sources can be described by two simultaneous binary choices of whether or not to supply local wage labor and whether or not to request financial support, as well as an outside labor supply function and a financial support demand function that are both left-censored at zero. Let dnf be an indicator for the household's decision to supply outside labor or not, and let dfs be an indicator for the decision to request financial support or not. The household's decision is described by one of four possible cases:

Case **1**: A corner solution for local wage labor supply and financial support demand: $dnf = 0$, $dfs = 0$ if $w < \bar{w}$ and $\alpha < \bar{\alpha}$, $l^{w*}(\Lambda) = 0$, $l^{R^*}(\Lambda) = 0$.

Case **2**: An interior solution for local labor supply and a corner solution for financial support: $dnf = 1, dfs = 0$ if $w = \bar{w}$ and $\alpha < \bar{\alpha}$, $l^{w*}(\Lambda) > 0$, $l^{R^*}(\Lambda) = 0$.

Case **3**: A corner solution for local labor supply and an interior solution for financial support: $dnf = 0, dfs = 1$ if $w < \bar{w}$ and $\alpha = \bar{\alpha}$, $l^{w*}(\Lambda) = 0$, $l^{R^*}(\Lambda) > 0$.

Case **4**: An interior solution for local labor supply and financial support demand: $dnf = 1, dfs = 1$ if $w = \bar{w}$ and $\alpha = \bar{\alpha}$, $l^{w*}(\Lambda) > 0$, $l^{R^*}(\Lambda) > 0$.

The conceptual model and subsequent discussion indicate that the choice between outside employment and financial support depends on the strength of interactions between human capital and family composition. Based on this theoretical discussion, our objective is to provide econometric evidence of the empirical determinants of income composition.

Equation [6] indicates that the optimal choice of non-fishing labor earnings and financial support follows a system of equations in which corner solutions are possible. In our sample, almost all fishermen are at a corner solution for one or both sources of non-fishing income. We therefore employ a two-part lognormal hurdle model that is appropriate for the presence of corner solutions (Wooldridge 2010).[15] This model simultaneously estimates the probabilities of earning positive non-fishing labor income and/or financial support (the participation decision in equation [7]), along with the quantities of both income sources (the amount decision in equation [7]),[16] as functions of a vector of schooling and family composition variables x_i, and a vector of control variables z_i. Following Wooldridge (2010), we can formally express the empirical model of non-fishing labor income and financial support for household i as

$$\begin{aligned} nf_i &= \mathbf{1}(x_i'\alpha_1 + z_i'\beta_1 + \epsilon_{1i} > 0) \cdot exp(x_i'\gamma_1 + z_i'\delta_1 + u_{1i}) \\ fs_i &= \mathbf{1}(x_i'\alpha_2 + z_i'\beta_2 + \epsilon_{2i} > 0) \cdot exp(x_i'\gamma_2 + z_i'\delta_2 + u_{2i})' \end{aligned} \qquad [7]$$

where $\mathbf{1}(.)$ is an indicator variable determined by a probit model. We assume (ϵ, u) are independent of (x, z), and that ϵ and u are independent of each other in each equation.[17] We make two further assumptions to reflect the fact that we observe very few fishermen at an interior solution for both sources of non-fishing income. First, we assume that (u_1, u_2) are independent of each other, which captures the absence of marginal tradeoffs in the "amount" decisions if one "amount" is always zero when the other is positive. Second, we allow (ϵ_1, ϵ_2) to follow a standard bivariate normal distribution with correlation parameter ρ, which captures the decreased likelihood of earning non-fishing labor income if financial support is not zero, and vice versa (and we therefore expect a negative estimate of ρ). This is formally equivalent to estimating a bivariate probit model on the participation dummy variables dnf_i and dfs_i and estimating separate linear models on the natural log of the non-zero income amounts lnf_i and lfs_i by maximum likelihood.[18, 19]

The parameters of interest are coefficients on the schooling and family composition variables, $\alpha_1, \alpha_2, \gamma_1,$ and γ_2. The vector x_i includes schooling, family size, and their interaction. We define schooling as 1 if the household head has at least a secondary education and 0 if not.[20] The vector of control variables z_i includes quadratic terms for the fishing captain's age, boat ownership status, boat type, and professional membership in fishermen's associations. We use the number of years living in the village as a proxy for age because the fishermen surveyed were not asked their age directly. Mobility among Malaysian fishing captains is very low, and the distribution of our age proxy is what would be expected from an age variable, with less than 10% of respondents reporting fewer than 15 years in the village, and 10% reporting more than 55 years. We define boat ownership as 1 if the fisherman owns the boat he operates and 0 otherwise, boat type as 1 if the boat is in a larger commercial class suitable for offshore fishing and 0 if the boat is in the smaller category suitable for inshore fishing, and membership as 1 if the fisherman is a member of a fishermen's association and 0 otherwise. These control variables generally capture the fishing captain's attachment to the fishing profession.[21] Finally, we include a vector of district dummy variables, Δ_d, to control for regional variation in market access and resource stock quality or abundance. We could not control for gender or ethnicity because all the surveyed fishermen are males, and 353 out of 354 are of Malay descent.

Data and Variables

We use the Malaysian Turtle Survey 2005, hereafter MTS-2005, which was conducted from September 20, 2005 to March 24, 2006. The survey was designed, supervised and administered by the Malaysian Department of Fisheries, the Turtle and Marine Ecosystem Centre, World Wildlife Fund-Malaysia, the National Oceanic and Atmospheric Administration-Fisheries, the Department of Economics at University of California San Diego, and The WorldFish Center (Yeo *et al.* 2007). Altogether, MTS-2005 surveyed a stratified random sample of 354 fishing captains from three states on the east coast of peninsular Malaysia. The survey sites begin near Kuantan in the state of Pahang up to the Besut district in the state of Terengganu and the Pasir Puteh district in the state of Kelantan. Respondents were asked questions about socioeconomic status, household characteristics, fishing operations and conservation attitudes, making it a uniquely detailed data source with which to empirically investigate the tradeoffs delineated in the previous section.[22] We assume that a fisherman, who is the principal income earner and the head of household, represents his corresponding household as the survey respondent.

Table 1 describes and summarizes the variables we use in the empirical analysis. Despite investing in new technologies and capital to maintain fishing productivity, many of the respondents state that they do not want their children involved in fishing, and that limitations in their own education or opportunity set prevent them from switching occupations permanently (Gilbert and Yeo 2014). Consistent with this notion, we find that the total household income comprises fishing and non-fishing incomes as well as financial support from live-in and live-away children. All the monetary units are expressed in Malaysian Ringgit (MYR), which was equivalent to USD 0.265 per unit on January 1, 2006. A typical fishing household earns MYR 816 and MYR 248 from fishing and non-fishing employments, and receives MYR 34 in financial supports from children, making its average household income of MYR 1,147. The average household size is 7.64. We find that although 74% of the fishermen have their own fishing boats, only 41% of those boats are larger vessels suitable for deep-sea fishing. Therefore, we control for both ownership and size of fishing boats in all our regressions to capture the potential variations in remittance and non-fishing employment seeking behaviors resulting from them.

The MTS-2005 dataset did not collect fishermen's age and years of schooling. However, since the fishermen typically do not move between villages, we use the number of years living in their villages of current residence as a proxy for their corresponding ages. This is a valid assumption since we find that, on average, fishermen live in their villages for more than 36 years. Next, in absence of any continuous measure of the years of schooling, we use secondary schooling, defined as 1 if the fisherman completed at least 10^{th} grade and 0 if not, as a measure of human capital influencing their non-fishing income earning capability. We find that only 30% of the surveyed fishermen have secondary schooling, which is consistent with their remittance-seeking behavior. Finally, we also control for fishermen's professional affiliations that might influence their likeliness to get access to income earning opportunities beyond fishing especially during the lean seasons. Table 1 shows that 84% of fishermen have membership in some kind of fisherman's association.

The MTS-2005 dataset also provides information on total fishing revenue, itemized costs of production, peak and lean season catches and earnings, properties of fishing vessels, and share of catch. Table 1 shows that the total revenue from the latest fishing trip amounts to MYR 2,952, which includes the shares for crews (27%), owners (54%), and the captain (14%), respectively. Besides, the total cost is MYR 254. In addition, there are considerable differences between peak and lean season earnings and catches: fishermen catch 2,508 kgs of fish during the peak seasons and earn MYR 4,898; whereas the corresponding figures stand only at 444 kgs and MYR 658 during the lean seasons. Average duration of the latest fishing trip was 26 hours, whereas the average number of people involved was 6. Moreover, average size of the fishing boats used were 11.42 feet in length and 3.34 feet in width; whereas those boats were equipped with 116hpb and 10.26 ton engines.

Next, Table 2 provides summary statistics for four categories of fishing households by their supplemental income decisions. The majority of the sample (60%) receives no outside income or financial support, while slightly more households earn local wage income than receive financial support (22% versus 16%). Only 2% of households receive both sources of supplemental income, which is consistent with our model's prediction that each source incurs a household opportunity cost. The calculation of financial support includes contributions from both the working-age children living with and away from their parents. For comparison purposes we estimate our econometric specifications using this total financial support calculation (Table 3), as well as the breakdown of financial support (remittances from live-away children versus contributions from live-in children as reported in Table 4).

The summary statics describing the profile of fishermen in different income-earning categories are consistent with previous literature (e.g., Abdulai and CroleRees 2001; Carter and Barrett 2006; Corral and Reardon 2001; Escobal 2001; Narain, Gupta, and van't Veld 2008). In general, financial support recipients (i.e., NF=0, FS>0) are the poorest in terms of total household income and outside income earners (i.e., NF>0, FS=0) are the richest. In addition, financial support recipients have lower schooling and greater family size than the outside income earners.

IV. REGRESSION RESULTS

Main Results

Table 3 reports the key parameter estimates and marginal effects from bivariate probit regressions based on equation [7].[23] A statistically significant value of ρ verifies the presence of cross-equation correlation in the participation decisions, justifying the use of bivariate probit models. The statistically significant χ^2 value of 170.5 verifies that the regressors are jointly significant. Further, the predicted probabilities of each of the four cases evaluated at the mean value of the regressors are very close to the corresponding sample frequencies in Table 2, validating our fitted models (Cameron and Trivedi 2010): 60% that no income diversification occurs, 15.9% that financial support is received but non-fishing labor income is not earned, 21.8% that non-fishing labor income is earned but no financial support is received, and 2.3% that both supplementary income sources are received. The following discussion of results focuses mainly on the relationship between schooling, family characteristics, and the choice between outside labor income and family financial support.

Columns (1) and (2) of Table 3 report participation decisions using family size as the single measure of family characteristics.[24] The estimated coefficients indicate that fishermen with larger families are more likely to receive financial support, but their likelihood of earning non-fishing labor income depends on their secondary schooling status; larger families decrease the likelihood of non-fishing labor earnings if the household head is not educated, but the opposite is true for educated household heads. The marginal effects show that educated households are 28.4% more likely to not diversify away from fishing income, but that likelihood decreases by 3.6% for each additional family member. An additional family member raises the probability of receiving financial support by 1.5%. Further, each additional family member decreases the likelihood of earning non-fishing labor income by 2.2% if the household head does not have secondary schooling – but this effect is more than offset by a 4.8% if the household head is educated.

Results in Table 3 are consistent with the possibility that financial support relaxes the household budget constraint and reduces the need for wage labor earnings by household members, as has been found under some conditions in Amuedo-Dorantes and Pozo (2006) and Grigorian and Melkonyan (2011). In this specification, financial support is calculated as the sum of contributions to household income from working age children living both inside and outside the home. In rural fishing households, working-age children living at home are often employed in the family fishing enterprise, so a greater family labor pool is likely to lead to more intensive fishing activities and fewer non-fishing work activities; those children are also likely to contribute some of their fishing income to the total household income, which would explain this result.

Columns (3) and (4) of Table 3 report estimated relationships with the amount decisions – the natural log of non-fishing labor income and family financial support. For non-fishing labor income, the signs of the coefficients generally match those of the participation decision; educated household heads are not only less likely to earn non-fishing labor income unless they have large families, but conditional on participating they also earn less, again unless they have large families. For financial support, however, educated household heads receive significantly more than uneducated ones unless they have large families. This may reflect educated household heads investing more in the human capital of their children, who are then better able to exit the fishery for better livelihoods. In fact, educated household heads are more likely to invest on the betterment of the future generations due to their higher allocative efficiency through higher degree of technology adoption (Abdulai and Huffman 2014; Abdulai and Huffman 2005; Huffman 1974; Wozniak 1984; Wozniak 1993). Large families, on the other hand, may have fewer resources to educate and/or fund the migration of their children, so their children may be more likely to work in the family fishing enterprise or in other local positions.[25]

We can see this more clearly by dividing the financial support variable into contributions from live-in working-age children and true remittances from migrants. Table 4 reports results obtained by allowing the models from Table 3 to have three participation equations and three amount equations in order to account for these two types of family financial support. Rather than a biprobit for the participation equations, we now estimate a triprobit model for the three binary dependent variables: whether or not the household earns non-fishing labor income as before, whether or not the household receives live-in contributions (denoted $dfs1$), and whether or not the household receives live-away remittances (denoted $dfs2$). Each amount equation is linear, with the natural log of the non-zero amounts of each income source as the dependent variable, estimated by maximum likelihood. As before, Table 4 reports the results with family size as the only measure of family characteristics. Note that the amount equations have fewer observations than previously because few households receive both types of family financial support. We therefore dropped several control variables in order to reduce the number of parameters estimated.

The results in Table 4 mostly corroborate those reported in Table 3, but help to clarify the channels. These results are again consistent with the interpretation that educated households prefer to invest in the human capital of a few potential migrants rather than seek local non-fishing labor earnings. Specifically, we see that:

1) a larger family size increases the *likelihood* of receiving any financial support from live-in working-age children (column (2) of Table 4);

2) however, a larger family size also decreases the *amount* of that type of support (column (5) of Table 4);

3) educated households are less likely to earn non-fishing labor income – and they earn less of it – while they receive *more* in migrant remittances, unless they have large families (columns (1), (4), and (6) of Table 4).

Education, Family Structure, and the Marginal Product of Fishing Labor

In this section, we investigate one channel through which human capital and family structure can affect income diversification: fishing productivity. As our model shows, human capital and family structure can affect non-fishing income decisions through either the marginal value product of fishing labor, or through the utility function (i.e., through shifts in the curves in Figures 1 and 2). For example, our finding that educated households are less likely to earn non-fishing labor income could result from an outward shift in the marginal value product of fishing labor, e.g., if educated captains are better fishermen. The same result could also be driven by an increase in the marginal utility of leisure, however, if education increases the value of home production. Similarly, differences in remittance receipts by education status could be driven by shifts in the marginal product of fishing labor or an increase in the marginal disutility of requesting financial support, e.g., if educated households feel more shame or guilt from relying on their adult children. In order to distinguish between these channels, we estimate the relationship between fishing productivity and education, fishing experience, and various measures of family labor. We estimate a log-linearized Cobb-Douglas production function of the form:

$$ln y_i = \alpha + \boldsymbol{w}_i'\boldsymbol{\theta}_w + \boldsymbol{x}_i'\boldsymbol{\theta}_x + \boldsymbol{z}_i'\boldsymbol{\theta}_z + \nu_i, \qquad [8]$$

where y_i is the fishing revenue from the most recent fishing trip, $\boldsymbol{w}_i$ is a vector of the natural log of production inputs from the most recent fishing trip, $\boldsymbol{x}_i$ is a vector of human capital and family labor variables, and $\boldsymbol{z}_i$ is a vector of control variables.[26] Production inputs include a flow measure of labor services and two measures of the vessel capital stock: total vessel size (calculated as the product of length and width in square meters) and engine horsepower. For labor services, we multiply the total number of workers on the fishing vessel during the most recent trip (including the captain) by the duration in hours of that trip. The vector $\boldsymbol{x}_i$ includes the secondary school attainment dummy, the number of years of fishing experience, and a measure of family labor constructed similarly to the total labor services variable. Because captains may employ their non-migrated adult working-age children on the boat, we calculate family labor services as the natural log of the product of the "Live-in Members" variable with the duration of the most recent trip.[27] The vector $\boldsymbol{z}_i$ includes district dummy variables.[28]

Table 5 reports regression estimates of our preferred specification for equation [8], without and with the human capital and family labor variables. The statistically significant output elasticities approximately sum to one in all specifications, indicating a constant returns to scale technology. The human capital and family labor variables are neither individually nor jointly statistically significant, as shown in column (2). This null result is robust in the specification that we estimated, including many not reported here. Although these results must be interpreted with caution because household labor allocation is endogenous to *expected* outcomes, the result is consistent with a large body of literature on productivity and skill in fisheries showing that systematic productivity differences between boats are not robustly explained by observables. Rather, some captains are simply more talented than others, or have private information about productive fishing locations.[29]

The evidence is therefore not consistent with the hypothesis that fishing productivity is the channel through which education and family structure affect income diversification. Interactions between human capital and family structure in the household utility function or educational spillovers from parents to migrant children are most likely driving income diversification.

V. DISCUSSION

Our results overall suggest that education and family size are determinants of non-fishing income decisions. It is more likely that education and family size interact in the household utility function, or affect potential non-fishing wages, than that they affect the fishing operations in a way that influences non-fishing income decisions. For example, the finding that educated households are less likely to receive any remittances unless they have a large family size is consistent with a shame or disutility of requesting remittances – if that shame is greater for educated households, but having more potential migrants (and potentially educated migrants if there are spillovers from parent to child) reduces the shame. Further, because education is associated with more remittances among households who receive positive remittances, education may increase the migrant's earning potential and therefore the amount that they remit. However, there are other possibilities for how education and family size interact to determine marginal utilities and we cannot disentangle competing explanations.

We can, however, consider a thought experiment on a set of policies that affect market variables exogenous to the household. For example, a typical fishing regulatory policy to conserve resources is to restrict fishing inputs through vessel size limitations, or seasonal or spatial closures. Such regulations are often less costly to implement and enforce than direct harvest restrictions, and are therefore common in both developing and developed country fisheries. Squires (2016) gives a detailed accounting of the consequences of such regulations in Malaysia, finding strong complementarities between fishing inputs. An enforced reduction in one input is therefore likely to reduce the marginal product of labor and shift in the fishing labor demand curve depicted in Figure 2. This has two possible consequences: first, to induce the household to supply more wage labor to the local market than was previously optimal, at a potentially lower reservation wage, and second, to reduce the marginal utility of leisure, which shifts out the supply curve of labor to distant markets, potentially inducing more out-migration even at low remittance rates.

An alternative policy could be to reduce the transactions costs of migrating and remitting. Urban centers in Malaysia are a major source of remittances to rural populations throughout Southeast Asia. Often migrants use informal, unlicensed, or illegal channels to transfer money back home, either to avoid transactions costs such as high banking fees, or as a result of scams or coercion by their employers (Hernandez-Coss *et al.* 2008). Migrating to an urban center in order to send remittances involves significant risks, particularly for international migrants moving to places where non-citizens and guest workers have few legal protections. Similarly, Amuedo-Dorantes and Pozo (2006) show that transactions costs for the home household also matter; the distance to a Western Union office or similar money transfer institution can affect remittance volume. Panel A of Figure 2 shows how reducing these transactions costs and effectively increasing the remittance rate for a given amount of migrant labor could reduce fishing activity in a way that improves household welfare, according to our model. If more family members migrate and remit, this raises the shadow cost of household labor and reduces the shadow cost of income, increasing the reservation wage for local wage work and lowering the equilibrium labor allocated to fishing. Consistent with this, Amuedo-Dorantes and Pozo (2006) find that the causal effect of remittances is to reduce both formal sector work and self-employment of men, which could be interpreted as fishing in our context. However, they also find an offsetting increase in informal sector work among men, which is wage employment without a contract. The bulk of non-fishing labor income in our setting likely falls in this category. Amuedo-Dorantes and Pozo interpret this as possibly being driven by disruptive costs of migrating that may affect the shadow value of income, but there may also be preferences over job type that are not captured by our model.

VI. SUMMARY AND CONCLUSIONS

By considering jointly-determined financial support as an alternative to non-fishing labor income, we find that schooling and family size are important determinants of income diversification by a household to supplement its fishing income. Fishing households may earn supplementary income from supplying labor to local wage employment, or request financial support from family members including income-earning children. Non-fishing labor supply directly adjusts both the time constraint and the income constraint, whereas financial support also affects household utility. Assuming leisure is a normal good, greater diversification in income may transfer labor from low-rewarding fishing activities to better-rewarding non-fishing activities, thereby increasing utility (e.g., Fafchamps and Quisumbing 1999; Holden, Shiferaw, and Pender 2004; Yang 1997a; Taylor and Yunez-Naude 2000).

We find that the effect of family size on this choice depends on the education level of the household head and vice versa. Uneducated fishermen with larger families have a lower probability of earning non-fishing labor income, and are more likely to receive contributions from live-in adult children who are most likely employed in the family fishing enterprise. Educated fishermen with fewer children, on the other hand, receive a greater volume of migrant remittances and are less likely to earn non-fishing labor income. This trend reverses for educated fishermen with larger families. Therefore, although education alone does not induce diversification away from fishing for the current generation, it does potentially enhance the reallocation of labor away from fishing at least for their children and may therefore have larger long-run effects on resource conservation. The important implications of our empirical findings are that educated households may more highly value, and invest in, the education of their children, which further alters the pattern of income diversification of resource-dependent households.

Thus, any policy intervention targeting either the conservation of the fishing sector or the development of non-fishing employment sectors, or more generally, employment sectors not dependent on natural resources, must focus on the development of education and family characteristics in the targeted community. In addition, our results suggest caution in basing policies on simple assumptions concerning the impacts of outside employment opportunities and financial support on the allocation of household labor to fishing. For example, given that outside employment and remittances increase income, it is tempting to conclude that an increased flow of financial support or a better opportunity of outside employment may lower a household's dependency on fishing. However, such a conclusion is too simplistic. As previous work has found, household members reallocate their resources, including labor time, in response to changes in economic conditions and the value of work they do (Huffman 1980; Shively and Fisher 2004). Our results suggest that this is certainly the case for fishing-dependent households in Malaysia, and that there is a major difference in the behavioral response of educated fishermen with smaller families as opposed to uneducated fishermen with larger households. If the overall objective is to reduce the dependence of poor households on fishing, then policies should be targeted at increasing the sources of income for uneducated fishermen with larger families. Furthermore, education and training policies should be considered on a generational time scale particularly if state-provided education can supplement parent-to-child human capital spillovers. Bringing down the cost of remittances has become a major policy objective of G20 nations in recent years (World Bank 2014) and the Central Bank of Malaysia has also made recent moves to regulate the remittance transfer industry and reduce remittance costs (bin Ibrahim 2015). More research is needed on the impact of such policies on rural natural resource management in recipient communities.

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TABLES

TABLE 1
Variable Description and Summary Statistics

Variables	Descriptions	Mean	S.D.	Min.	Max
Schooling	Dummy: 1 if the fisherman is at least secondary educated, 0 if not	0.30	0.46	0	1
Fishing Income	Monthly total fishing income (MYR)	816.24	2896.15	0	50000
Non-fishing Income	Monthly total non-fishing labor income (MYR)	247.97	1065.37	0	13000
Live-in contributions	Financial support received from live-in children (MYR)	14.15	66.40	0	600
Live-away Remittances	Financial support received from live-away children (MYR)	19.39	75.75	0	750
Family Size	Total number of family members	7.64	3.51	1	35
Age	Proxy for age: Number of year the fisherman living in the village	36.46	15.88	1	80
Boat Ownership	Dummy: 1 if the fisherman owns the fishing boat, 0 if not	0.74	0.44	0	1
Boat Size	Dummy: 1 if bigger boat, 0 if smaller boat	0.41	0.49	0	1
Membership	Dummy: 1 if the fisherman has any professional membership, 0 if not	0.84	0.37	0	1
Total fishing revenue	Total revenue earned from the last fishing trip (MYR)	2951.64	12205.11	0	162005
Total cost	total (input) cost in the last fishing trip (MYR)	253.91	328.16	0	2152.8
Peak earning	Captain's total fishing income during the peak season (MYR)	4897.85	23293.55	25	380000
Lean earning	Captain's total fishing income during the lean season (MYR)	657.64	2019.51	0	16000
Peak catch	Total catch (kg) during peak season	2507.67	8012.01	0	100000
Lean catch	Total catch (kg) during the lean season	443.88	1696.09	0	15000
Trip people	Number of people in the latest trip	6.35	8.35	1	40
Trip duration	No. of hours spent in last trip	26.17	49.59	1	373
Boat length	Length of the boat used in the latest trip	11.42	6.43	2	40
Boat width	Width of the boat used in the latest trip	3.34	2.06	0.83	15
Horsepower	Horsepower of the boat engine in the latest trip	115.52	226.42	1.30	3000
Tonnage	Gross tonnage of the boat in the latest trip	10.26	16.07	0.02	160
Owner share	Owner's % share of total catch	0.54	0.30	0	1
Captain share	Captain's % share of total catch	0.14	0.18	0	1
Crew share	Crew's % share of total catch	0.27	0.20	0	0.8

Notes: Total number of observation is 354. (Monthly) income figures are in 2005 Malaysian Ringgit. We define fiber boats, lesen sampan and zone-A boats as smaller, and zones B and C boats as bigger boats.

TABLE 2
Summary Statistics by Groups

	Groups			
Variables	NF=0, FS=0	NF>0, FS=0	NF=0, FS>0	NF>0, FS>0
Schooling	0.32	0.35	0.15	0.14
	(0.47)	(0.48)	(0.36)	(0.38)
Fishing Income	1023.74	464.36	524.55	685.71
	(3703.53)	(366.07)	(275.28)	(452.51)
Non-fishing Income		1069.87		619.00
		(2063.58)		(654.12)
Live-in contributions			75.64	121.43
			(129.83)	(223.34)
Live-away Remittances			103.00	171.43
			(132.64)	(264.35)
Family Size	7.48	6.81	9.16	9.29
	(3.32)	(2.83)	(4.55)	(2.21)
Age	35.38	36.40	40.04	42.14
	(15.70)	(14.24)	(18.54)	(13.63)
Boat Ownership	0.73	0.72	0.80	0.86
	(0.44)	(0.45)	(0.40)	(0.38)
Boat Size	0.44	0.31	0.47	0.14
	(0.50)	(0.46)	(0.50)	(0.38)
Membership	0.79	0.92	0.87	1.00
	(0.41)	(0.27)	(0.34)	(0.00)
Total fishing revenue	3934.01	1827.12	1058.28	576.29
	(15217.24)	(5675.16)	(2694.52)	(987.03)
Total cost	295.38	197.64	184.22	165.90
	(365.01)	(290.82)	(176.62)	(288.76)
Peak earning	4279.32	8818.36	1909.79	4676.00
	(10929.14)	(46571.11)	(3846.97)	(5818.15)
Lean earning	691.38	893.91	250.02	136.00
	(1835.79)	(2953.16)	(834.10)	(260.25)
Peak catch	2754.60	2953.08	1038.82	1591.67
	(6695.98)	(12520.66)	(3025.18)	(2275.61)
Lean catch	471.04	517.01	266.31	171.67
	(1575.88)	(2200.85)	(1406.50)	(405.83)
Trip people	7.39	4.90	4.69	4.29
	(9.33)	(6.98)	(5.48)	(5.35)
Trip duration	32.30	16.91	16.23	19.96
	(55.90)	(44.29)	(20.96)	(35.31)
Boat length	12.31	9.69	10.41	11.84
	(6.94)	(5.74)	(4.75)	(4.71)
Boat width	3.63	2.80	2.96	3.41
	(2.17)	(2.06)	(1.38)	(1.57)
Horsepower	128.42	109.41	81.22	61.14
	(241.70)	(250.46)	(111.15)	(63.61)
Tonnage	12.27	6.53	8.13	6.84
	(18.80)	(10.25)	(9.94)	(6.74)
Owner share	0.52	0.59	0.55	0.49
	(0.29)	(0.29)	(0.31)	(0.31)
Captain share	0.14	0.14	0.12	0.14
	(0.18)	(0.18)	(0.21)	(0.21)
Crew share	0.29	0.21	0.27	0.30
	(0.21)	(0.17)	(0.20)	(0.24)
Number of observations	214 (60.45%)	78 (22.03%)	55 (15.54%)	7 (1.98%)

Notes: Standard deviations in parentheses, unless otherwise mentioned. (Monthly) income figures are in 2005 Malaysian Ringgit. NF and FS, respectively, stand for non-fishing incomes and financial support. We define fiber boats, lesen sampan and zone-A boats as smaller, and zones B and C boats as bigger boats.

TABLE 3
Non-fishing Labor Income and Financial Support

Variables	(1) Participation equations (Bivariate probit coefficients and marginal effects) dnf [P10]	(2) dfs [P01]	[P00]	(3) Amount equations (Linear maximum likelihood) lnf	(4) lfs
Schooling	-0.725**	-0.536		-1.374**	2.991***
	(0.365)	(0.420)		(0.659)	(0.884)
	[-0.161]*	*[-0.079]*	*[0.284**]*		
Family Size	-0.081***	0.064**		0.004	0.042
	(0.026)	(0.030)		(0.051)	(0.028)
	*[-0.022***]*	*[0.015**]*	*[0.008]*		
Schooling*Size	0.125***	0.025		0.155*	-0.286**
	(0.048)	(0.047)		(0.085)	(0.114)
	*[0.030***]*	*[0.000]*	*[-0.036**]*		
Age	0.038*	-0.019		0.087**	-0.013
	(0.019)	(0.019)		(0.043)	(0.019)
	*[0.010**]*	*[-0.005]*	*[-0.006]*		
Squared Age	-0.001*	0.000		-0.001*	0.000
	(0.000)	(0.000)		(0.001)	(0.000)
	*[-0.000**]*	*[0.000*]*	*[0.000]*		
Boat Ownership	-0.207	0.041		0.079	0.227
	(0.159)	(0.207)		(0.317)	(0.354)
	[-0.053]	*[0.015]*	*[0.044]*		
Boat Size	-0.234	0.377*		0.395	-0.173
	(0.232)	(0.206)		(0.326)	(0.193)
	[-0.072]	*[0.081**]*	*[-0.014]*		
Membership	0.693***	0.414		0.269	-0.437
	(0.217)	(0.257)		(0.412)	(0.280)
	*[0.158***]*	*[0.056]*	*[-0.252***]*		
District dummies	YES	YES		YES	YES
Observations	339			81	61
chi2	170.5***				
Wald test of rho=0: chi2(1)	7.71**				
Pseudo-R^2				0.0899	0.105
F statistics				4.483***	5.557***
Tests of joint significance					
(1)	9.37*			2.20	9.74***
(2)	17.45***			3.88**	3.23**
(3)	24.76***			2.69**	6.53***

Notes: Coefficient standard errors clustered at the village level are in parentheses, and marginal effects are in bracketed italics. ***,** and * represent statistical significance of 1%, 5% and 10%, respectively. Dependent variables dnf and dfs, respectively, are binary outcomes denoting non-fishing wage income (1 if the fisherman earns any non-fishing wage income and 0 if not) and financial support (1 if the fisherman receives any financial support from children and 0 if not), and logged values of non-fishing labor income (i.e., lnf) and financial support (i.e., lfs). We denote P10=Pr(NF>0, FS=0), P01=Pr(NF=0, FS>0), and P00=Pr(NF=0, FS=0). The null hypotheses in tests of joint significance are (1) *Schooling and Schooling-Family interactions are jointly zero*, (2) *Family and Schooling-Family interactions are jointly zero*, (3) *Schooling, Family, and Schooling-Family interactions are jointly zero*.

TABLE 4
Non-fishing Labor Income and Financial Support: Separating Live-in Adult Children and Migrants

	(1)	(2)	(3)	(4)	(5)	(6)
	Participation equations (Trivariate probit coefficients)			Amount equations (Linear maximum likelihood)		
Variables	dnf	$dfs1$	$dfs2$	lnf	$lfs1$	$lfs2$
Schooling	-0.720*	-0.011	-0.804	-1.289*	-3.298	3.694***
	(0.369)	(0.846)	(0.513)	(0.717)	(6.390)	(0.663)
Family Size	-0.079***	0.124***	0.030	0.010	-0.034	-0.008
	(0.026)	(0.031)	(0.029)	(0.051)	(0.030)	(0.035)
Schooling*Size	0.121**	-0.059	0.071	0.136	0.447	-0.330***
	(0.047)	(0.046)	(0.050)	(0.093)	(0.883)	(0.077)
Age	0.035*			0.090**		
	(0.018)			(0.043)		
Squared Age	-0.000*			-0.001*		
	(0.000)			(0.001)		
Boat Ownership	-0.142		-0.145	0.039		0.712*
	(0.156)		(0.250)	(0.337)		(0.389)
Boat Size		0.109	0.391*		0.340	-0.020
		(0.325)	(0.226)		(0.254)	(0.275)
Membership	0.700***	0.131	0.587**	0.204	-0.342	-0.160
	(0.206)	(0.342)	(0.239)	(0.411)	(0.256)	(0.380)
District dummies	YES	YES	YES	YES	YES	YES
Observations	339	339	339	81	28	39
Tests of joint significance						
(1)	14.74**			1.77	0.14	20.61***
(2)	47.11***			3.01*	0.69	10.39***
(3)	76.25***			2.15	0.51	13.93***

Notes: Coefficient standard errors clustered at the village level are in parentheses. ***,** and * represent statistical significance of 1%, 5% and 10%, respectively. Dependent variables dnf and dfs, respectively, are binary outcomes denoting non-fishing wage income (1 if the fisherman earns any non-fishing wage income and 0 if not) and financial support (1 if the fisherman receives any financial support from children and 0 if not), and logged values of non-fishing labor income (i.e., lnf), live-in contributions (i.e., $lfs1$) and live-away remittances (i.e., $lfs2$). The null hypotheses in tests of joint significance are (1) *Schooling and Schooling-Family interactions are jointly zero*, (2) *Family and Schooling-Family interactions are jointly zero*, (3) *Schooling, Family, and Schooling-Family interactions are jointly zero*.

TABLE 5
Fishing Productivity and Secondary School Attainment

Variables	(1)	(2)
Total Labor Services	0.49***	0.49***
	(0.09)	(0.09)
Boat Area	0.24*	0.25*
	(0.13)	(0.14)
Engine Horsepower	0.27**	0.23*
	(0.12)	(0.12)
Live-in Members		0.07
		(0.04)
Schooling		0.15
		(0.24)
Experience		0.02
		(0.03)
Squared Experience		-0.00
		(0.00)
District dummies	YES	YES
Observations	309	309
R-squared	0.55	0.55
Tests of joint significance of Live-in Members, Schooling, and Experience		
F		1.49
p-value		0.21

Notes: Standard errors clustered at the village level are in parentheses. ***,** and * represent statistical significance of 1%, 5% and 10%, respectively. The dependent variable is the natural log of fishing revenue earned during the respondent's most recent fishing trip. The explanatory variables are also in natural logs, except for Schooling which is a dummy variable that takes the value of one if the respondent has a secondary education, and Experience which is measured in years. District dummies are included in each regression; their coefficients are available upon request.

FIGURES

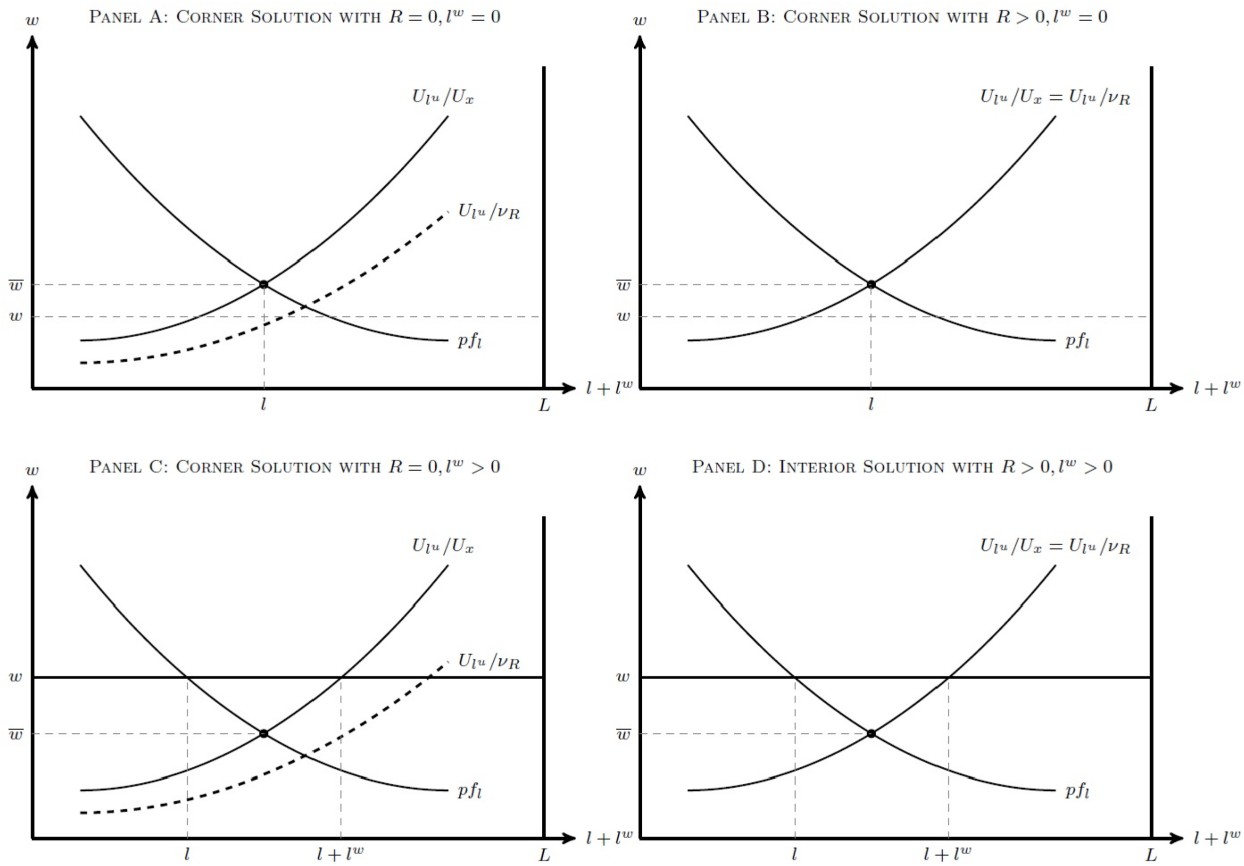

Figure 1 – Optimal solutions

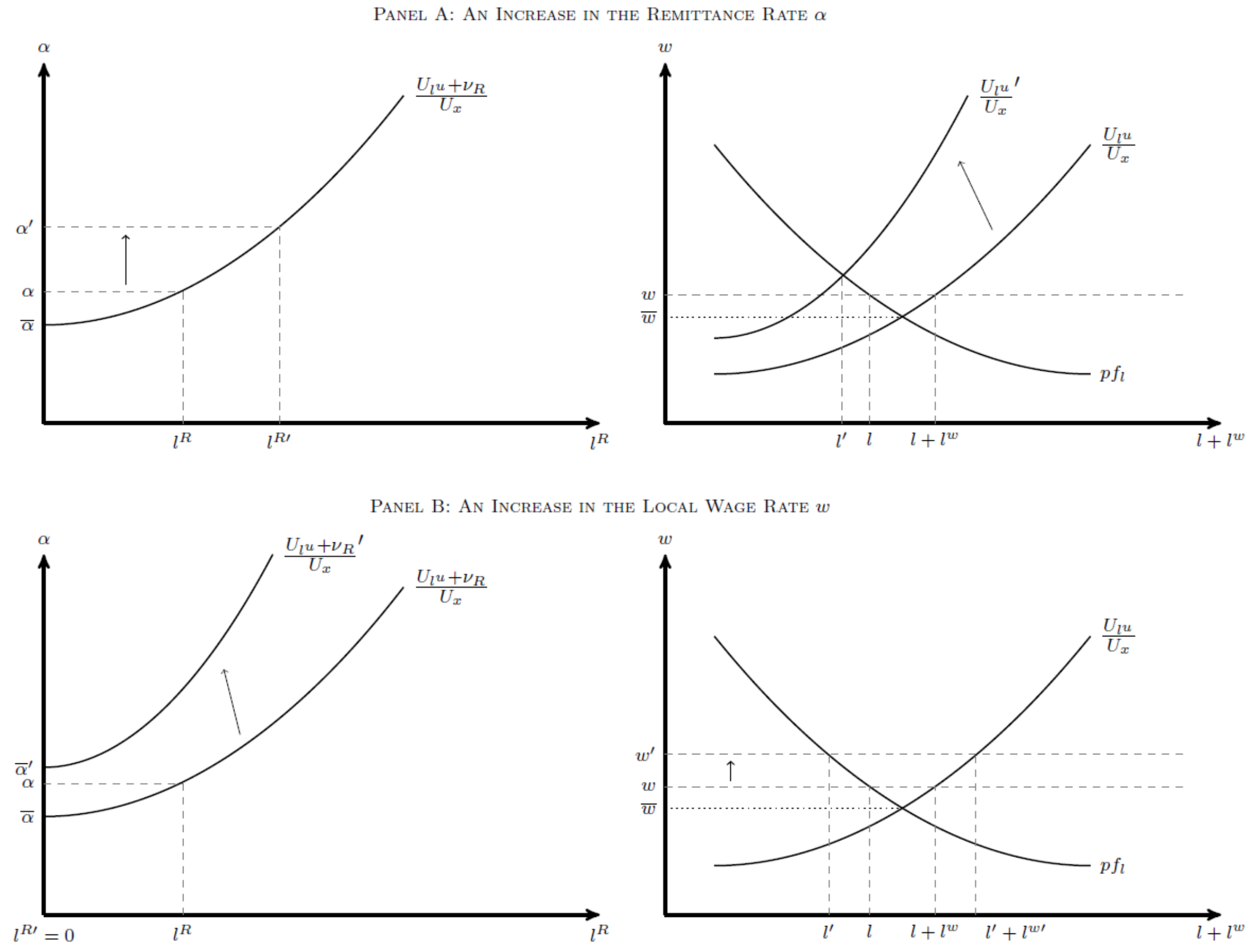

Figure 2 – Comparative statics

[1] For example, Takasaki, Barham, and Coomes (2010) found that, irrespective of labor and capital endowments, riverine households in the Peruvian Amazon intensify fishing effort through increased ex post labor supply in smoothing income in response to crop losses caused by large floods.

[2] Exceptions include Coomes, Barham, and Takasaki (2004), Takasaki, Barham, and Coomes (2004), Barbier (2007), Barbier (2010), and Reddy, Groves, and Nagavarapu (2014). However, none these papers considers the issue of remittance demand jointly with off-resource labor supply.

[3] For example, Kirkley, Squires and Strand (1998) find a positive relationship between education and productivity in a U.S. fishery; Viswanathan *et al.* (2002) and Susilowati *et al.* (2005) find no relationship in Malaysian and Indonesian fisheries (respectively); Gilbert and Yeo (2014) find a negative relationship among an artisanal subsample of the Malaysian vessels studied in this paper; and finally Squires *et al.* (2003) find different relationships in fisheries on different sides of Peninsular Malaysia. One interpretation is that the relationship between education and fishing productivity may depend on the development status and market integration of the fishery being studied.

[4] Existing literature on remittances focuses on either the microeconomic determinants of the likeliness and flow of remittances or the macroeconomic impacts of the flow of remittances (e.g., Lucas and Stark 1985; Rapoport and Docquier 2006; Yang 2011; Brown and Jimenez-Soto 2014). Microeconomic literature primarily focuses on the determinants and motives of migrants' remittances: while the decision to migrate depends on migrant's characteristics (Funkhouser 1995), likeliness and flow of remittances are determined by migrants' motives to remit such as altruism, self-interest, loan repayment, inheritances (Lucas and Stark 1985; Rapoport and Docquier 2006). One exception is McCormick and Wahba (2000), who considered both the demand and supply sides in a simple general equilibrium model, still with heavy emphasis on the supply side and policy implications for brain-drain.

[5] For example, McCormick and Wahba (2000) assumed unlimited land resources available to the agricultural sector in migrant's source country when drawing direct implications for brain-drain. However, their model is not suitable to study natural resource management in a decaying industry.

[6] The LH model was chosen as the best fit among a class of two part Tobit models for the presence of optimally-chosen corner solutions (as opposed to incidental truncation or sample selection) (Wooldridge 2010).

[7] There may be differences in labor endowment by gender, age, or migratory status. An alternative approach would be to consider a joint household utility function that takes the utility of different categories of household members as separate arguments, with separate labor time constraints (e.g., migrants and non-migrants, males and females, parents and children). This is the approach, for example, in McCormick and Wahba (2000) who model the joint household utility of migrants and non-migrants. A more detailed approach serves McCormick & Wahba's purpose to develop a multi-sector general equilibrium model of both the local and the distant labor market. The purpose of our model is to motivate our empirical study and clarify the key tradeoffs for the household, and we do not observe gender differences in household composition, detailed age information about members other than the household head, or information about the migrants' labor market. For our purpose, a more detailed approach like McCormick & Wahba's applied to different categories of household membership substantially complicates the model without providing additional insight for what we can observe with our data. Our simplified approach nevertheless treats each household member's labor supply as an integral part of the household's jointly optimal resource allocation, which is in the spirit of the NELM literature.

[8] Associating disutility with financial support from children has some indirect support in the literature. Apart from altruism, which is empirically less robust, other motives behind remitting money from children to parents include tacit agreements regarding future financial and asset transfers from parents to children (e.g., Lucas and Stark 1985; Yang 2011). Especially in the case of more than one child, such financial support from one child can bias the future allocation of inheritances. Such obligations may also generate disutility for the household head.

[9] Since we do not have any information of host sector, we define risk in terms of fishing income. Therefore, the relationship between risk and remittances empirically resembles to investigating the altruism motive (e.g., Amuedo-Dorantes and Pozo 2006). Amuedo-Dorantes and Pozo (2006) argued that if migrants remit more in response risks in home encountered by the left-behind family members, migrants' remittance-sending behavior is consistent with altruism and inconsistent with insurance.

[10] Common motives for migrants' remittances include asset accumulation, insurance and altruism. Irrespective of the motive, remittances help rural households to smooth their income especially in response to income shocks (Yang and Choi 2007; Amuedo-Dorantes and Pozo 2011), which is particularly true for the poor households from developing

countries often experience lack of reliable social insurance programs, inadequate liquid savings, and binding borrowing constraints (Amuedo-Dorantes and Pozo 2011). Especially since credit constraint restricts relatively deprived or poorer households and individuals from moving from agriculture to modern sector (Banerjee and Newman 1998), and temporary migrants are more likely to remit more (Dustmann and Mestres 2010), internal temporary migration is a common coping strategy in many developing countries (Gröger and Zylberberg 2016). Gröger and Zylberberg (2016) found that Vietnamese households with settled migrants ex ante receive more remittances; whereas non-migrant households send family members away to diversify the sources of income.

[11] We have accounted for the number of dependent children attending school, the number of nonworking dependents (e.g., smaller children and elderly relatives), as well as the number of adult, working-age children living either at home (i.e., live-in) or away from home (i.e., live-away), which allows for the possibility that not all working-age family members contribute to the household labor endowment. Literature identifying these determinants include, among others, Lucas and Stark (1985), Faini (1994), McCormick and Wahba (2000), Funkhouser (1995) and Yang (2011).

[12] For simplicity, we analyze a static setting and do not explicitly model the dynamics of capital accumulation or resource stock growth and depletion. The average boat in our sample is halfway through the expected total lifespan of 18 years, so our assumption that marginal labor supply and financial support demand decisions are made conditional on predetermined capital choices is reasonable in the context of our empirical application. Our setup also implicitly assumes that all boats have equal access to resource stocks and equal exposure to fishing regulations N. In our empirical setting stocks may vary across allowable fishing zones within different regions, but access to different fishing zones is determined by vessel type, and we control for vessel type and location in our econometric specifications.

[13] This simplification follows the works of Gisser (1965), Gould and Soupe (1989), Huffman and Lange (1989), Schultz (1988), Sumner (1982), Yang (1997a), among others. Schultz (1988) documented that higher schooling often leads farming households to prioritize off-farm employment over farm labor. Gisser (1965) and Huffman (1980) find that education increases the off-farm employment of farm operators. Huffman and Lange (1989) and Gould and Soupe (1989) find that a husband or wife with higher schooling has a significantly greater probability of engaging in nonfarm jobs.

[14] In our empirical application, almost all of the households are in Panels A, B, or C – very few pursue outside employment and receive remittances – but those that do have larger than average families and lower than average

secondary school attainment (see Table 1). It is also worth noting that only the cases in Panels C and D, in which positive non-fishing labor is supplied, are fully recursive in the sense that labor supply and leisure demand decisions can be made independently because the market wage for non-fishing labor equates the marginal values of labor and leisure along a continuum of allocations (Jacoby 1993), and none of the cases allow labor allocation and remittance demand decisions to be made independently. Our empirical approach will specifically allow for dependence across the labor supply and remittance demand decisions.

[15] A standard Type I Tobit model, a Truncated Normal Hurdle model (Cragg 1971), and an Exponential Type II Tobit (ET2T) model (Wooldridge 2010) produced qualitatively similar results and were rejected in favor of the Lognormal Hurdle model on the basis of model fit using Likelihood Ratio tests and Vuong's (1989) tests. The ET2T model allows for correlation between the errors in the participation equation and the errors in the amount equation, and is most similar to the well-known Heckman two-step approach (Heckman 1976), except that the outcome is defined by an exponential function. Our ET2T estimates of the correlation between the participation and amount equations (available upon request) were either marginally significant or not statistically significant and of the wrong sign, even when allowing for an exclusion restriction, and the fit of the ET2T model is inferior to the LH model. This is consistent with the discussion and findings in Wooldridge (2010) for labor supply data. We therefore favor the LH model in the reported results. The additional results for all models are available upon request.

[16] This is consistent with Carling (2008), who argued that remittances decisions are made in two-steps: 1) whether to remit or not, and 2) if yes, how much to remit.

[17] This last assumption is relaxed in the ET2T model, which we rule out empirically in results that are available upon request. See footnote 15.

[18] Our model departs from Wooldridge's exposition of the LH model only in that we allow a system of two participation and two amount equations, with correlation across the participation equations. Our approach is otherwise identical to Wooldridge (2010).

[19] Such log-transformations of dependent variables greatly reduce the variances and skewness and kurtosis statistics, and, therefore, justify the use of lognormal models (e.g., Cameron and Trivedi 2010).

[20] We unfortunately do not have a continuous measure for educational attainment. The survey instrument asks respondents whether they have completed primary school or secondary school, and the majority of the variation occurs at secondary school attainment.

[21] Our findings are also robust to the inclusion of a control for total fishing earnings, which captures the need for supplementary income. Because fishing earnings are also endogenous to the household labor allocation problem, we omit this variable in reported results.

[22] Details of the data collection can be found in Yeo *et al.* (2007).

[23] We do not report the district dummies in the regression tables, but coefficients are available upon request.

[24] We use the notation P11=Pr(NF>0, FS>0), P10=Pr(NF>0, FS=0), P01=Pr(NF=0, FS>0) and P00=Pr(NF=0, FS=0).

[25] As an additional exercise to better understand how educational attainment creates a divergent effect of family size, we disaggregate the family size variable into the three family composition variables: student household members and adult live-in and live-away members. The estimated results are consistent with those reported in Table 3. However, there are two important caveats associated with these family composition variables. First, respondents do not directly provide the number of working-age children living outside the home (i.e., the number of migrants), although they do directly provide the total family size and the number of students and working-age children living inside the household, as well as the amount of money contributed to household income by live-in working-age children and working-age children living outside the home. We proxy for the number of working-age children living outside the home using the total family size, less the number of school age children and the working-age children living in the home. While this proxy may overestimate the number of migrants if there are also infant children or elderly family members living at home, our results are more consistent with the likelihood that this variable captures the intended variation. Second, the allocation of family members by the household to school, local work, and migrant work is endogenous to the total remittance and non-fishing labor earnings. We do not include this specification in main text due to the unavailability of direct measures of family composition variables in the MTS-2005 dataset; rather left them as a potential future research using an appropriate dataset.

[26] For detailed information about fishing activity, the survey instrument asks about the most recent fishing trip because survey respondents can recall recent events more accurately than they can guess their annual totals or monthly averages.

[27] We do not know which captains in our sample employ their children on their fishing boat. Results from specifications that exclude potential family labor or use alternative measures of family labor are almost identical to those reported here and are available upon request.

[28] In unreported results, we tested a large number of specifications of equation [8], all of which are consistent with the reported results. We included vessel gross tonnage and estimated [8] with each combination of capital stock variables; we augmented family labor services with both live-in working-age and school-age children together and separately; we replaced the family labor services variable with total family size and the product of family size with trip duration, in logs and levels; we included interactions between family labor services, human capital variables, and production inputs; and we controlled for membership in a fisherman's organization. We report the model with the greatest number of zero restrictions on the $\boldsymbol{w_i}$ and $\boldsymbol{z_i}$ vectors that could not be rejected, and a parsimonious set of human capital and family labor variables $\boldsymbol{x_i}$ that conveys the robust result.

[29] See, for example, Kirkley, Squires and Strand (1998); Viswanathan *et al.* (2002); Susilowati *et al.* (2005); Gilbert and Yeo (2014); and Squires *et al.* (2003) as discussed in footnote 3.