Intra-Household Gender Dynamics and Sustainable Agricultural Technology Adoption

Evidence from Indonesian Rural Households

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Motivation

- What are intra-household dynamics?
- How do they affect bargaining processes/mechanisms between husband and wife?
- How do they work in the rural agricultural communities?

Motivation

- Most poor people in the developing world rely in agriculture as their livelihood
- However, they faced with two pressing issues, in the presence of climate change: (1) Productivity; and (2) Sustainability.

Causes of low productivity

- Natural climatic factors[1]
- Pests and diseases[2]
- Limited use of fertiliser and inadequate attention to managing soil fertility
- Poor planting materials and ageing stocks
- Intercropping (causing lower yields –but suits the poorer farmers[3])
- Diversified livelihoods

Motivating questions

(1) How to promote sustainable agricultural techniques within the farming household

(2) How to improve the household decision-making process?

Productivity

Respond to market demand and food security

Sustainability

... without compromising environmental integrity

Gender dimension in agricultural household

- Comparison between male-headed and female-headed households [5, 6]
- Comparison between male plot managers and female plot managers [7, 8]
- However, the gender of the head/plot manager is not always a suitable indicator of decision making for the entire farm
- The possibility of a joint mechanism in which males and females in farming households make decisions together

Literature review

- **This study treats household decision-making related to farming activities as an individualised decision of the husband (as in most cases in patriarchal societies)**

Female intra-household bargaining power

- Years of education
- Non-farm work diversification
- Participation in formal work
- Spousal income generation activities
- Assets (land, inheritance)
- Participation in formal or informal networks

Research questions

1. To what extent does the wife's education and non-farm labour participation affect the husband's agricultural technology adoption decisions?
2. How do the dynamics affect the husband's perception of the technology
3. Do such dynamics affect the social networks of the husband, as the external factors affect the adoption decision

(1) Non-farm work, education, and AgriTech adoption

- Higher education is associated with access to information and analytical ability to process more complex information
- ... thus higher likelihood to adopt sustainable agricultural techniques
- But highly educated farmers also tend to deviate from full-time farming works, to achieve optimum income diversification strategy
- ... with time constraints, farmers working off-farm works will have limited management time to work on their fields, hence effects of education may be mixed

(1) Corresponding hypotheses

Hypothesis 1

1. The years of education of husbands and wives have positive effects on the adoption of sustainable practices

Hypothesis 2

1. The adoption occurs because households with better educated husbands and wives are more likely to be informed of the cost and benefits of such technologies

(2)Non-farm work type, education, and AgriTech adoption

- Perception and cost-benefit analysis of using agricultural technology matters
- Farmers may have to calculate labour costs, input (fertilisers) cost, and weigh the benefits accordingly
- Hence, type of non-farm works (informal vs formal) matters for making an informed decision regarding AgriTech
- Participation in certain non-farm work may enable farmers to be more informed of the costs and benefits of using the technologies

(2) Corresponding hypotheses

Hypothesis 3

1. Households with husbands and wives participating in formal works, are more likely to adopt sustainable agricultural practices

Hypothesis 4

1. The adoption happens because households with husbands and wives participating in formal work, are more likely to be informed of the costs and benefits of such technologies

(3)Non-farm work, education, and social networks

- In the rural communities when formal extension systems are lacking, farmers tend to rely on social networks
- Farmers learn about agricultural technologies from neighbors (through learning by doing)[4])
- Information on agricultural matters are transmitted through social interactions, hence the numbers of agricultural advise networks matter
- Types of network ties: bonding ties (links between people who have similar characteristics) vs bridging ties (links between people in the communities and people outside the communities)

(3) Corresponding hypothesis

Hypothesis 5

1. Households with husband and wife working off-farm are more likely to possess larger and deeper social networks, enabling them to obtain more information and revise their knowledge simultaneously

Major coffee producers

Figure 1. Exports of coffee and coffee products by major producers (in metric tons)

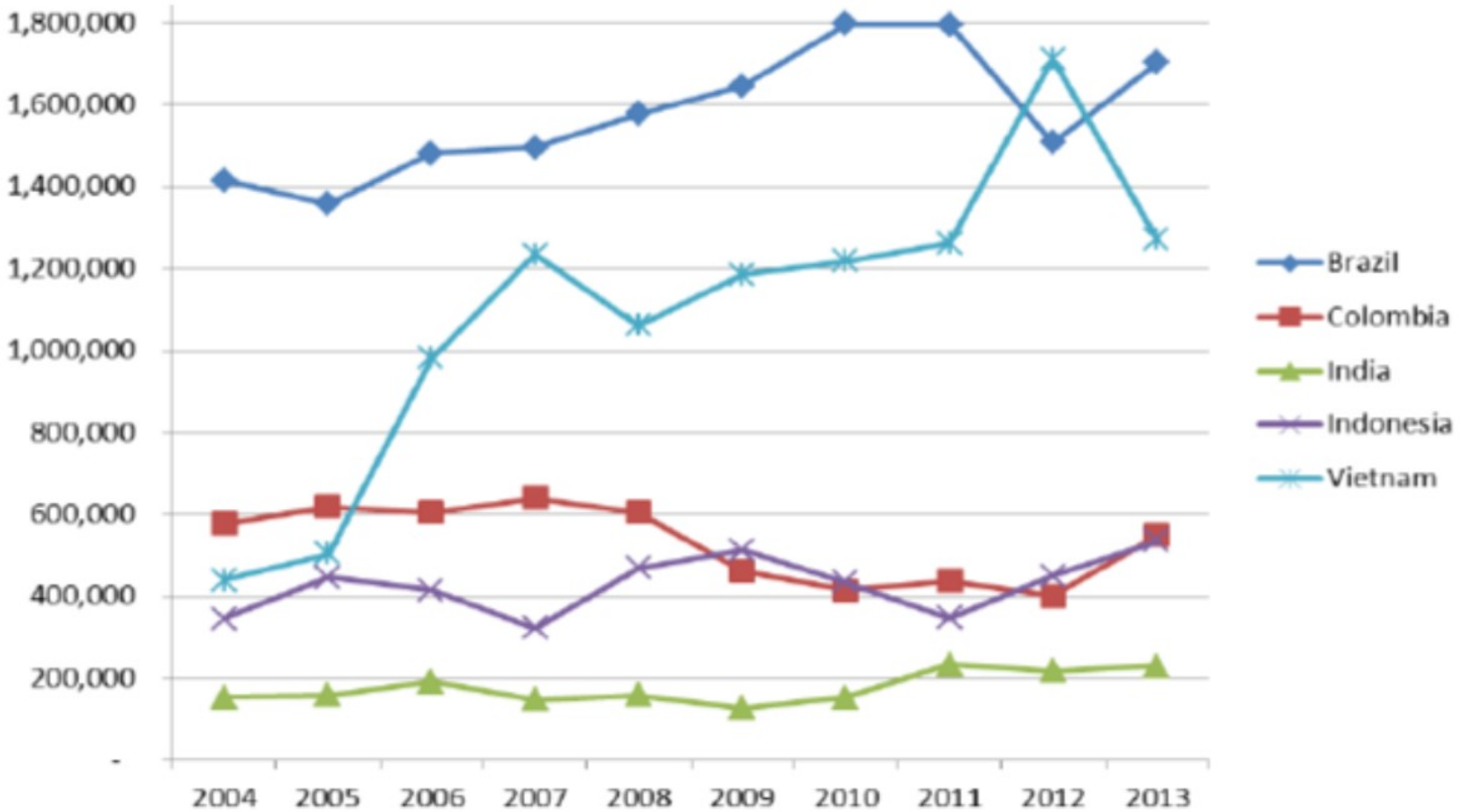


Figura: Source: UNCOMTRADE(2014)

Coffee producing area

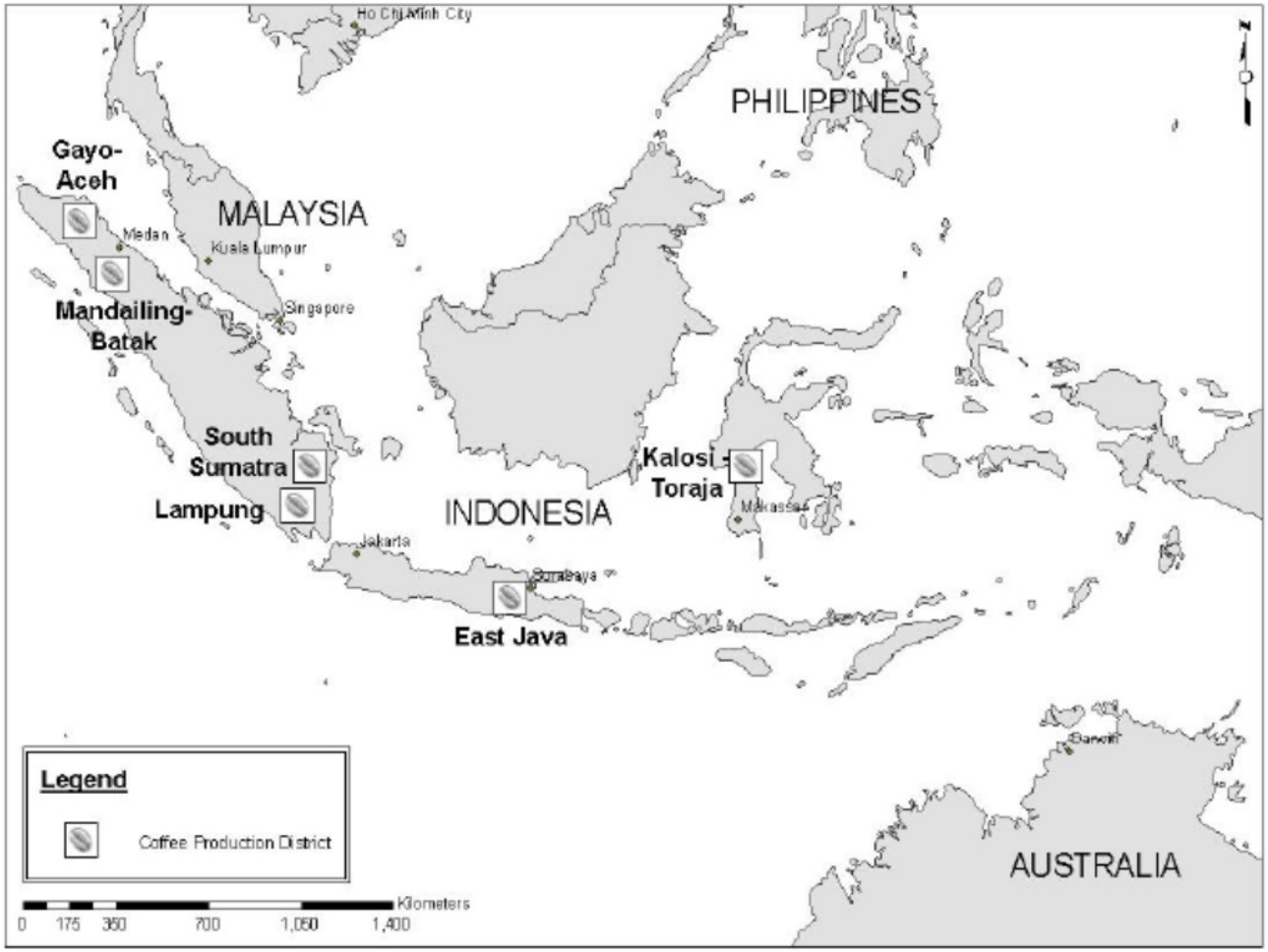
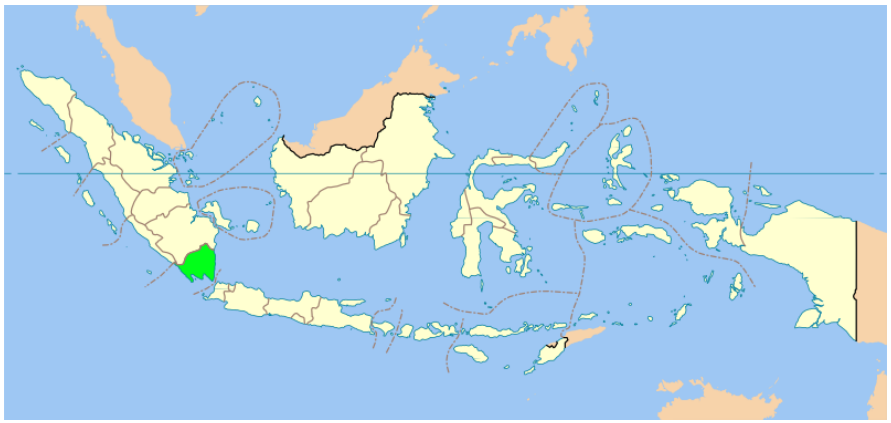
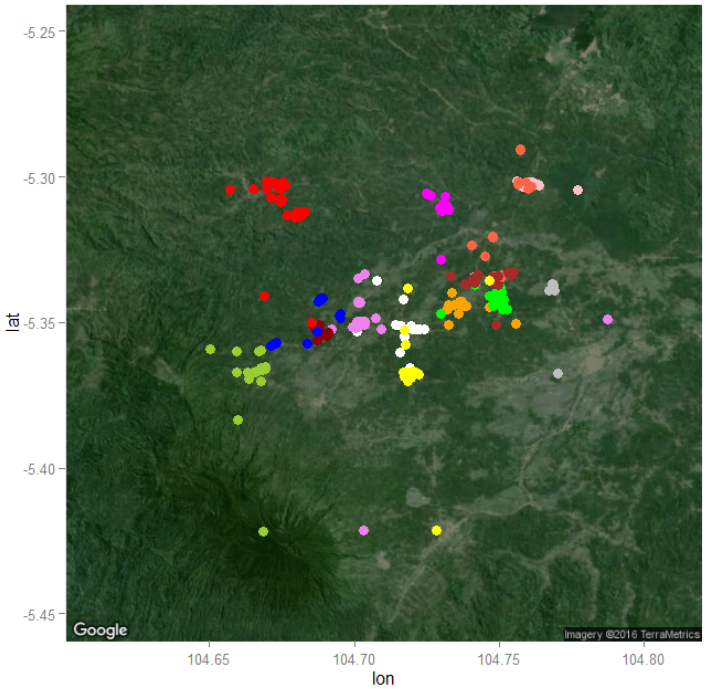


Figura: Source: Nielson (2014)

Lampung province





- One of major Robusta coffee and cocoa producer in Indonesia
- Total Area: 2,731.61 km2
- Population: 548.728 (in 2013)
- Density: 200,88 people/km2
- Total Farmland: 91.620,64 Ha

Methodologies

- Farmers group: 20-30 households usually cultivating the same commodities, listed under government's census
- 16 out of 36 randomly selected farmers groups based on regional census in 2008 in Sumberejo and Pulau Panggung sub-districts
- Listed 398 coffee/cocoa farmers as their members in 2012, surveyed 312 ($\tilde{8}0\%$) in 2012, 2013, and 2014

Sustainable agricultural techniques: Cultivation stage

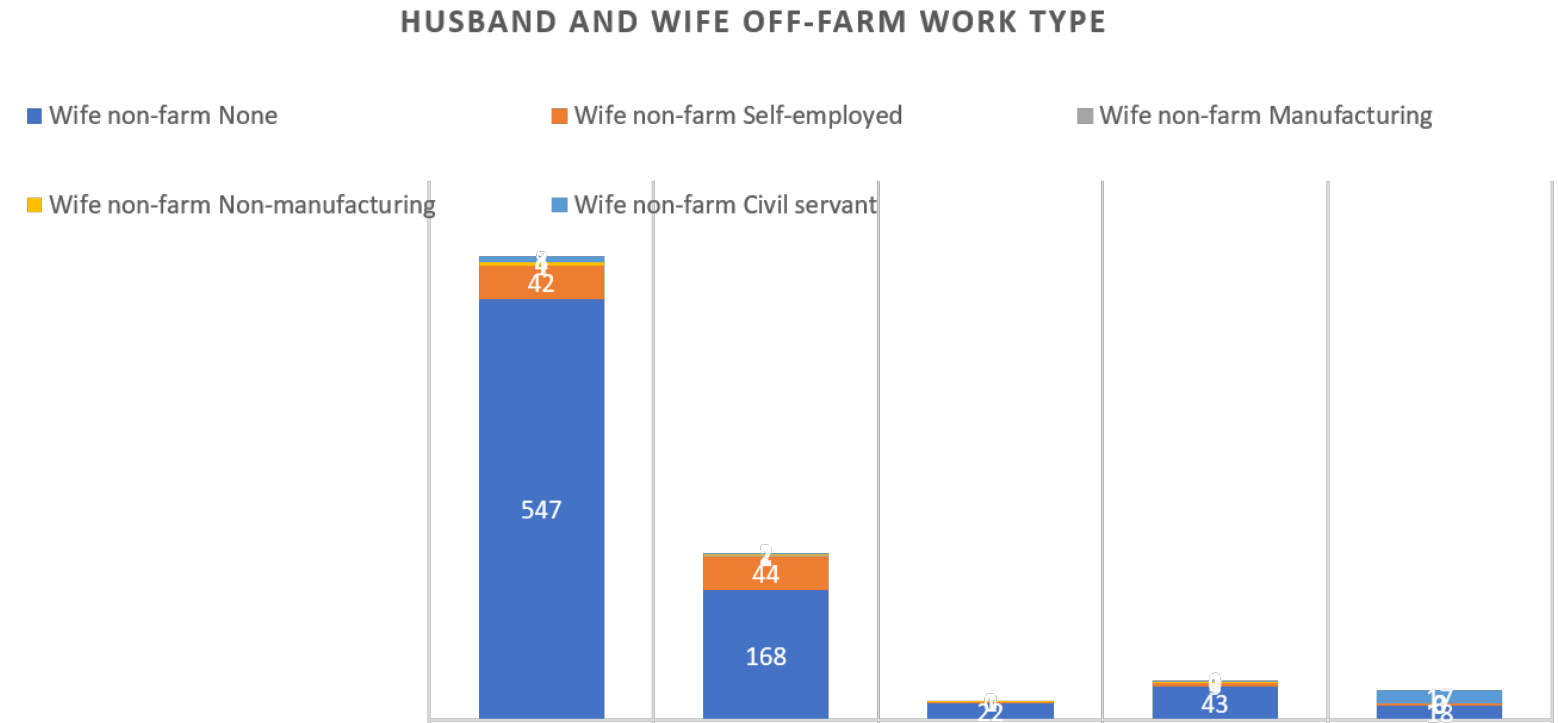
- Soil and water conservation techniques (improving the soil structure and porosity; and increasing the ability to bind water)
- Grafting methods (combining new varieties with strong root stocks and tree-trunks)
- Intensification methods: Organic and chemical fertilisers

Conservation technique

Side- and bud-grafting method

Organic and chemical fertilisers

Non-farm work type of husband and wife



	Husband None	Husband Self-employed	Husband Manufacturing	Husband Non-manufacturing	Husband Civil servant
Wife non-farm Civil servant	8	2	0	1	17
Wife non-farm Non-manufacturing	4	2	1	2	0
Wife non-farm Manufacturing	1	1	0	0	0
Wife non-farm Self-employed	42	44	1	5	3
Wife non-farm None	547	168	22	43	18

Adoption between full-time and part-time farmers

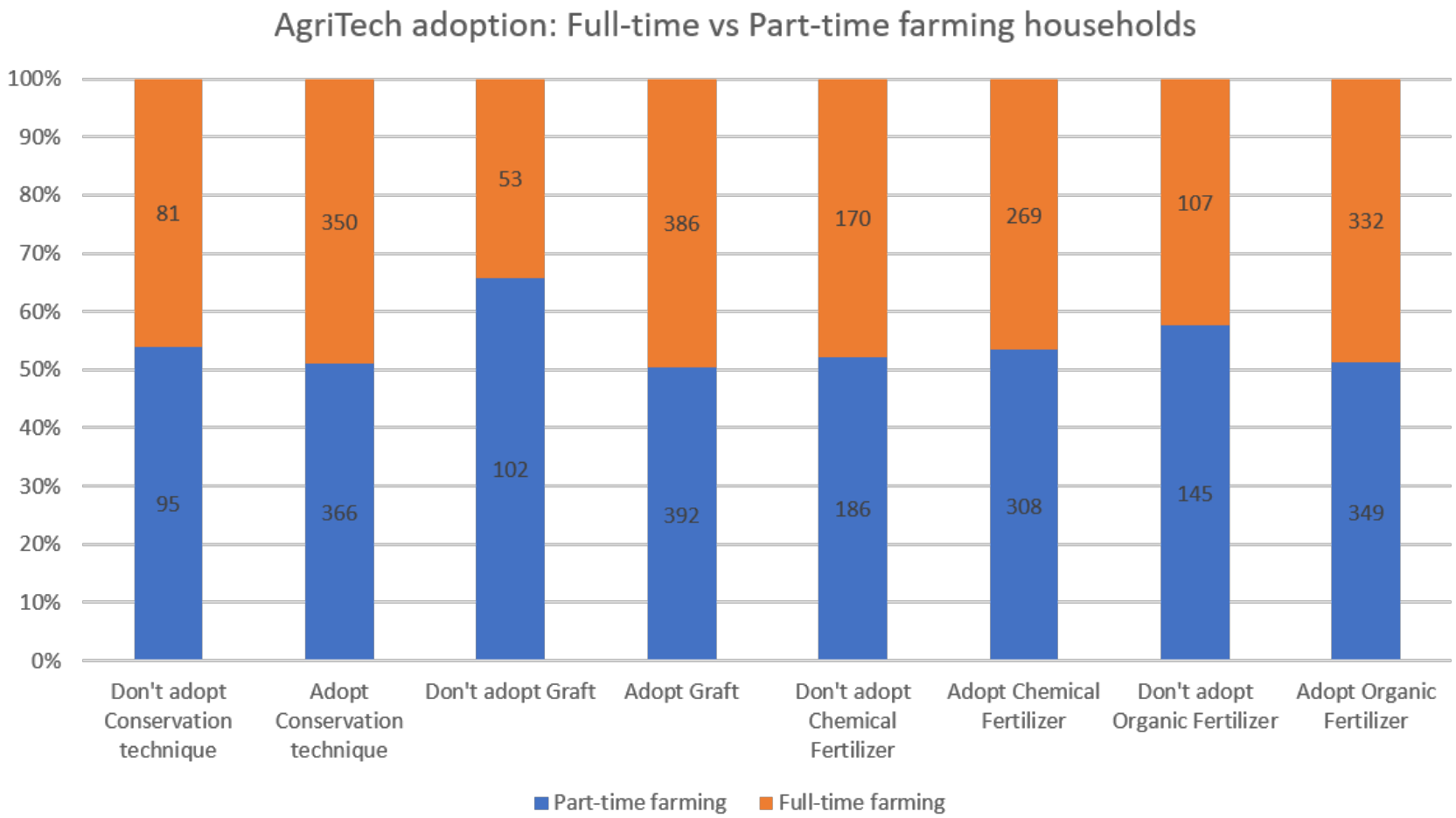


Figura: Part-time farmers defined as either husband or wife engaged in off-farm work

Estimation strategy

- Dependent variable:
  1. Dummy variable (0,1) of agricultural techniques adoption decision
  2. Dummy variable (0,1) of perception of agricultural techniques
  3. Social networks of the husbands, comprising network size and network structure
- Independent variable of interest:
  1. Non-farm status $\times$ Years of education;
  2. Share of non-farm income $\times$ Years of education;
  3. Non-farm status $\times$ Type of off-farm works.
- Control variables: village dummy, ethnicity dummy, year dummy, years of education
- Methods: marginal probability effects (MPE) of probit and logit model for dichotomous variables; fixed-effects regression for social network variables

DV: Adoption and perception of agricultural technology

Our dependent variables Y_{it} comprise the adoption and perception of agricultural innovation in dummy variables (0,1). Unlike the adoption variables, the perception variables are available as a cross sectional dataset in 2014, which we examine as follow:

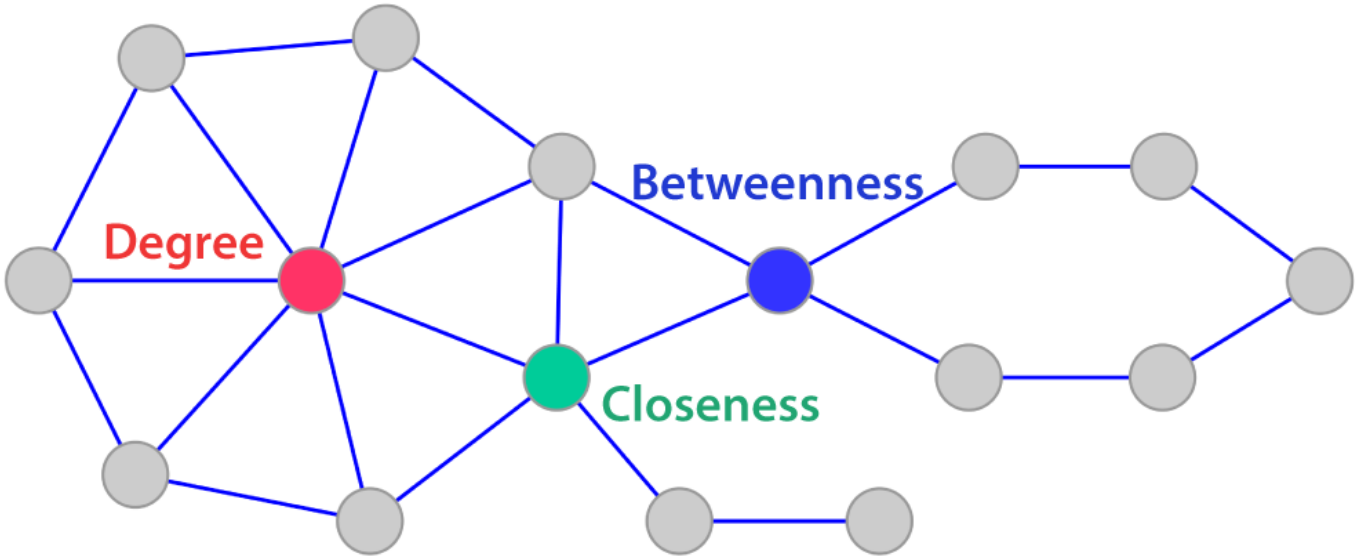
1. Chemical pest management
   - Is it easier to access than the natural one?
   - Does it pollute the water more than the natural one?
2. Chemical fertiliser
   - Is it easily available, able to enhance productivity, inexpensive, and good for the global environment?
   - Will it pollute the water around my field?
3. Organic fertiliser
   - Is it easily available, able to enhance productivity, inexpensive, and good for the global environment?

DV: Social networks

Questions asked: Names of the people from whom they seek advice and information pertaining to coffee and cocoa farming (up to 20 names in total, with the details of each person mentioned i.e. frequency, modes of contact)

1. **Network size**
   - Numbers of networks a household has, that belong to either farming group or outside the farming group, and both.
2. **Network structures**
   - **Degree centrality** A farmer with a higher degree of centrality maintains more contacts with other farmers and is considered relatively influential in the networks of farmers.
   - **Betweenness centrality** Farmer with a high betweenness centrality are interesting because they lie on communication paths and can control information flow.

Network structure: Illustration



Degree	ClosenessCentrality	BetweennessCentrality
7	0.45454545	0.29047619
5	0.51724138	0.42380952
4	0.48387097	0.4952381

Figura: Centrality measures

Image source: Cytoscape

Network structure: Farmers group no.1 in 2012

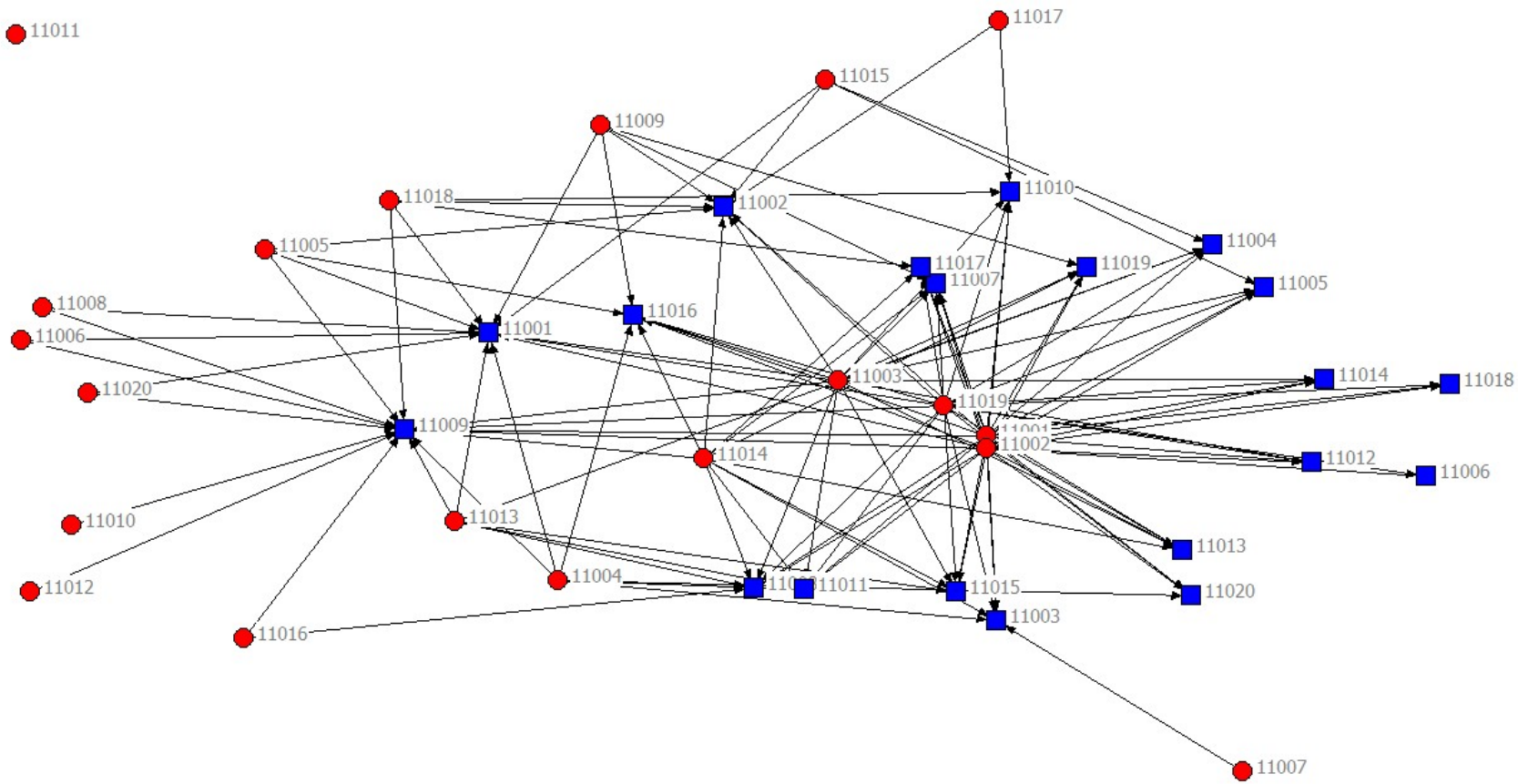


Figura: Centrality measures of Group 1 in 2012

1. Non-farm income, education, and adoption

- Education × Share of off-farm income are not significant
  –off-farm income not necessarily becoming investment in farm
- Years of education matters
  - One additional years of spouse education, increased probability of adopting conservation techniques by 7 percentage points
  - One additional years of husband education, increased probability of adopting organic fertilizer by 10 percentage points
- Findings support the first hypothesis: years of education of husbands and wives have positive effects on adoption

2. Non-farm income, education, and perception

- Higher educated wives working off-farm focused on environmental tradeoff; while the husbands on productivity
- The wives agree with:
  1. Chemical pest management pollutes the water
  2. Chemical pest management is easily available
  3. Chemical fertilizer pollutes the water
- The husbands agree with:
  1. Organic fertilizer increases productivity
- Second hypothesis supported: education makes one informed of the cost and benefits, despite gendered preferences

3. Off-farm work status and off-farm work type

- Civil servant wives associated with 160 percentage points more likelihood to adopt conservation techniques, and 87 percentage points to disadopt chemical fertilizer
- ...while the husbands with similar profile focus on productivity and intensification strategy i.e. grafting methods, chemical, and organic fertilizers
- Third hypothesis supported: formal works affected wives' bargaining power, influencing husband's preferences in adoption of innovation

4. Off-farm status, work type and perception of chemical

- Self-employed wives adept at environmental tradeoff, agree with:
  1. Chemical fertilizer pollutes the water (by 33 percentage points)
  2. Government wants farmers to use organic fertilizer (by 18 percentage points)
  3. Organic fertilizer is good for the global environment (by 14 percentage points)
- ..while the self-employed and civil servant husbands do not mention pollution at all –focused on productivity
- Self-employment made one more receptive of new information regardless of the gender.
- Hypothesis fourth only partially supported –wives working self-employed (not formal works) aware of the tech cost-benefits

5. Social networks: Network structures

- Wife's years of education and higher off-farm income share hurts their husband's network position in their respective farmers group
- ..and husbands with similar profile, tend to be the gatekeeper of information inside their locality

6. Social networks: Network size

- Non-farm works enlarge the husbands' networks from inside and outside the communities.
- Hypothesis 5 only partially supported, that only households with husband working off-farm having larger networks

Discussions (1)

- Why years of education, regardless of the part-time farming, status might be a sole predictor of adoption?
  1. Improved techniques may be a rational strategy to increase productivity with little investment as a utility maximisation strategy
  2. A gender-nuanced behavior found: that females are more environmentally aware than the males
- Strategies to promote environmentally sound practices for males should focus on profitability, and for females they should focus on the "negative" effects of doing/not doing something

Discussions (2)

- A well-educated wife is likely to be employed in a formal workplace, and is possibly sensitive to the environment, such as civil servants, for example.
  1. Peer-effect in the workplace may change her thoughts and opinion on climate change
  2. .. hence the increased decision-making power that affects their husband's technology preferences
- We find that self-employment may yield better judgment in cost-benefit analysis of using such technologies, regardless of gender.
- Wife's intra-household bargaining is associated with a weaker network position of their husband inside his locality.

Policy recommendations

- Gendered differences are pronounced in the adoption and perception of agricultural techniques, with females more likely to focus on negative environmental impacts and the males more likely to place emphasis on productivity
  1. Targeting the males: messages to revise the cost-benefit, in the long run, sustainable techniques will bring them greater benefits than the use of chemicals
  2. Targeting the females: focus on negative messages (?)
- Gender-focused extension services that technologically empower females in farming households are needed
  1. probably channeled through ROSCA (Arisan)
  2. women empowerment may have significant spillover effects on other well-being indicators at the household-level, hence multiple benefits

Thank you

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Image source in slide 2,3,7 and 8: https://pixabay.com/

APPENDIX LIST

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Non-farm income of husband and wife

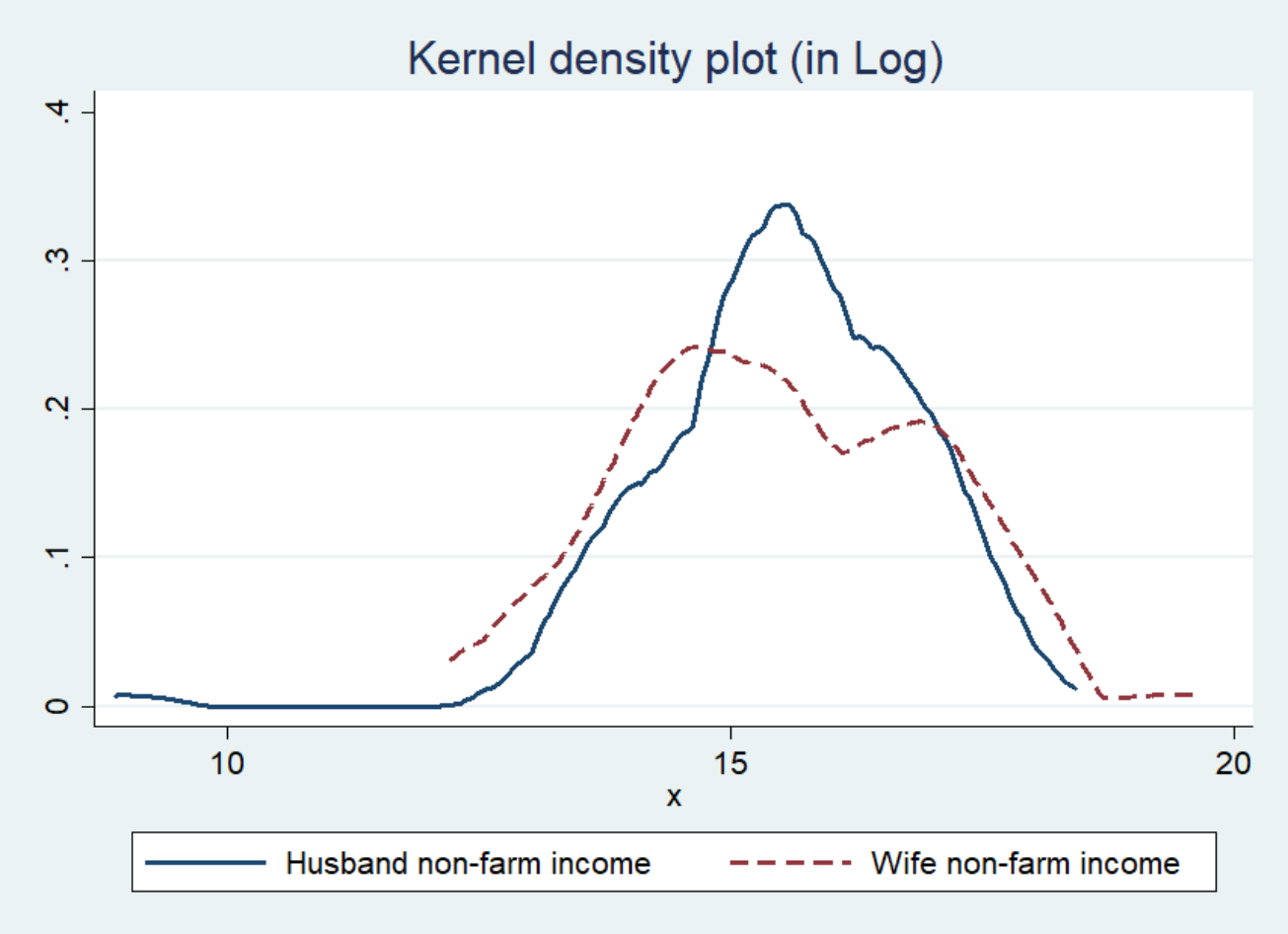

Figura: Kernel density plot of log of husband and wife non-farm income

Summary statistics: Full-time vs Part-time farmers

Variables	(1) Fulltime Farming Household		(1) Part-time Farming Household		(1) diff
	Mean	SD	Mean	SD	p
Education					
Age of head	47.305	12.012	44.176	10.484	0.000
years of schooling of head	7.344	2.973	9.412	3.488	0.000
Age of spouse	41.449	10.391	39.655	10.119	0.009
years of education of spouse	7.487	2.770	8.726	3.361	0.000
spouse with at least completed primary school	0.909	0.288	0.951	0.215	0.012
spouse with at least completed secondary school	0.442	0.497	0.735	0.442	0.000
Total years of schooling of husband and wife combined	14.831	5.174	18.249	5.984	0.000
Household characteristics					
No of elderly over 70 years old in the household	0.128	0.360	0.074	0.310	0.019
No of household members	4.064	1.289	3.915	1.289	0.088
Household head born in Lampung and not from Lampung ethnic	0.579	0.494	0.664	0.473	0.007
Assets					
No of car	0.018	0.134	0.119	0.377	0.000
Mobile phone possession (=1 if yes)	0.866	0.341	0.820	0.385	0.055

Figura: Summary statistics

Adoption and perception of agricultural technology

Individual family members will adopt optimum strategy sets that maximize their perceived benefits. Let the perceived benefits derived from adoption set by farmer i at time t, be:

$$Y_{it} = X_{it}\beta + u_{it} + c_i \qquad i = 1, \ldots n, \text{ and } t = 1, \ldots T \tag{1}$$

where, X_{it} is a set of observable covariates, β is a vector of parameter estimates, u_{it} is the normally distributed error term independent of X_{it}, and c_i are the time-invariant unobserved effects (Greene 2003; Hsiao 2014), such as the innate ability of individuals.

Adoption and perception of agricultural technology

We evaluate the marginal probability effects (MPE) of explanatory variables to adopt a technology or understand perception of such technology based on Probit and Logit model.We estimate:

$$\frac{\partial P(Adoption\ or\ Perception = 1)}{\partial x_{it,j}} = \varnothing\left(x_{it}^{'}\beta\right)\beta_j \qquad MPE\ in\ Probit \quad (2)$$

here t implies the year of 2012, 2013, and 2014;
Adoption or Perception $= 1$ denotes adoption and perception of the technologies, while *Adoption or Perception* $= 0$ denotes otherwise; x_{it} represents relevant household characteristics in each year of 2012, 2013, and 2014; β is the vector of coefficients to be estimated; $\varnothing\left(x_{it}^{'}\beta\right)$ is the value of the standard normal probability density function at $\left(x_{it}^{'}\beta\right)$.

Networks structures(1)

1. Degree centrality

$$C(D^i) = \sum_{k \neq i}^{n} A_{i,j} \tag{3}$$

Degree centrality uses adjacency matrix A for unweighted networks, which is defined as a $|V| \times |V|$ matrix with entries $A_{i,j} = 1$ if and only if farmer i and j connects, else zero.
As we used the normalized score of centrality, the maximum value of possible degree centrality attained is 1 if a farmer consulted with everyone in his farmer's group.

Networks structures (2)

2. Betweenness centrality

$$C(B^k) = \sum_{i \neq j \neq k \neq i}^{n} P_{ij}(k)/P_{ij} \tag{4}$$

Betweenness centrality used path matrix P, which is defined as a $|V| \times |V|$ matrix with $P_{i,j} = 1$ entries being equal to the number of shortest paths between farmer i and j. If no paths exist between vertices i and j, $P_{i,j}$ is set to zero and $P_{i,i}$ is set to one. $P_{i,j}$ denotes the number of shortest paths from farmer i to j, and $P_{i,j(k)}$ denotes the number of shortest paths from farmer i to j connecting via farmer k.

1. Non-farm income, education, and adoption

Variable	Adopt Conserv Technique	Adopt Grafting Method	Adopt Organic Fertilizer	Adopt Chemical Fertilizer
Wife educ×Share off-farm income	×	×	×	×
Husband educ×Share off-farm income	×	×	×	×
Wife years of education	0.0663* (0.0403)	×	×	×
Husband years of education	×	×	0.0973** (0.0393)	×

Tabela: MPE in Panel Probit model (Std.error clustered in household-level)

- Education × Share of off-farm income are not significant –not necessarily becoming investment in farm work, although education matters

2. Non-farm status, education, and perception

Variable	Chemical pest mngment pollutes the water	Chemical pest mngment easily available	Chemical fertilizer pollutes the water	Organic fertilizer increases productivity
Wife off-farm×Education	0.0314*	0.0439**	0.0599***	×
	(0.0187)	(0.0204)	(0.0200)	
Husband off-farm×Education	×	×	×	0.0195**
				(0.0096)

Tabela: MPE in cross-sectional Probit (Std.error clustered in household-level)

- Higher educated wives working off-farm are focused on environmental tradeoff while the husbands are concerned about productivity

3. Off-farm work status and off-farm work type

Variable	Adopt Conservation Technique	Adopt Grafting Method	Adopt Chemical Fertilizer	Adopt Organic Fertilizer
Wife off-farm × Wife civil servant	1.668**	×	-0.866**	×
	(0.681)		(0.345)	
Husband off-farm × Husband self-employed	0.581*	0.854***	×	0.659**
	(0.331)	(0.313)		(0.260)
Husband off-farm × Husband manufacturing	×	×	×	0.874**
				(0.396)
Husband off-farm × Husband non-mnfg	×	0.770*	×	×
		(0.432)		
Husband off-farm × Husband civil servant	×	1.535***	0.736*	×
		(0.520)	(0.432)	

Tabela: MPE in Panel Probit model (Std.error clustered in household-level)

- Civil servant wives lean towards sustainable techniques, while the husbands with similar profile tend to focus on intensification strategy.

4. Off-farm status, work type and perception of chemical

Variable	Chemical fertilizer increases productivity	Chemical fertilizer pollutes the water	Chemical fertilizer inexpensive	Chemical fertilizer easily available
Wife off-farm × Wife self-employed	×	0.313**	×	×
		(0.130)		
Husband off-farm × Husband self-employed	0.221***	×	0.346*	×
	(0.0819)		(0.196)	
Husband off-farm × Husband civil servant	0.396***	×	0.505**	0.475**
	(0.118)		(0.222)	(0.219)
Husband off-farm × Husband non-manufacturing	×	×	×	0.389*
				(0.218)

Tabela: MPE in cross-sectional Probit (Std.error clustered in household-level)

- Self-employed wives are more adept at environmental tradeoff of using chemical, while the self-employed and civil servant husbands are better at calculating profits for productivity

5. Off-farm status, work type and perception of organic (1)

Variables	Government wants farmers to use organic fertilizer	Organic fertilizer is good for the global environment	Organic fertilizer inexpensive	Organic fertilizer easily available
Wife off-farm × Wife self-employed	0.178**	0.144*	×	0.139**
	(0.0768)	(0.0794)		(0.0630)
Husband off-farm × Husband self-employed	0.218***	0.219***	0.165***	0.165***
	(0.0723)	(0.0830)	(0.0524)	(0.0629)
Husband off-farm × Husband non-manufacturing	0.198*	0.216**	0.164**	×
	(0.112)	(0.102)	(0.0784)	
Husband off-farm × Husband civil servant	×	×	0.216***	×
			(0.0606)	

Tabela: MPE in cross-sectional Probit (Std.error clustered in household-level)

- Entrepreneurship lines of work made one to be more receptive of new information regardless of the gender.

6. Off-farm status, work type and perception of organic (2)

Variables	Organic fertilizer increases productivity	Consumers prefer coffee and cocoa grown with organic fertilizer	Combining chemical and organic is best for productivity
Wife off-farm × Wife self-employed	×	×	×
Husband off-farm × Husband self-employed	0.204***	0.420***	0.283**
	(0.0734)	(0.108)	(0.134)
Husband off-farm × Husband non-manufacturing	×	0.254*	0.530***
		(0.131)	(0.173)
Husband off-farm × Husband civil servant	×	0.316**	0.483***
		(0.137)	(0.186)

Tabela: MPE in cross-sectional Probit (Std.error clustered in household-level)

- Still, male is more focused on productivity, even more so if he is self-employed.

7. Social networks: Network structures

Variables	Degree Centrality	Betweenness Centrality
Wife educ years×Wife share of off-farm income	-0.0211**	×
	(0.0111)	
Husband educ years×Husband share of off-farm income	×	0.0104**
		(0.0041)

Tabela: Fixed-effects regression (Std.error clustered in household-level)

- Wife's years of education and higher off-farm income share hurts their husband's network position in their respective farmers group –or wife with stronger intra-household bargaining is associated with their husband's network position.
- ..and husbands with similar profile, tend to be the gatekeeper of information inside their locality