SERICULTURE ADOPTION AND POVERTY REDUCTION ON RWANDA'S THOUSAND HILLS

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OUTLINE

- UTEXRWA's Silkhills: innovation for business turnaround
- Sericulture adoption as an innovation in a poor, landlocked country
- Sericulture adoption as an employment creation and poverty reduction strategy
- Impact evaluation methodology: propensity score matching(PSM)
- Data
- Results
- Conclusion

FROM MULBERRY LEAVES TO A SILK GOWN

- What is sericulture?
  - Silk worm rearing
  - Cocoon production
  - Silk reeling
- Utexrwa and silk fabrics
- Silkhills: high value creation and new market development

WHEN BUSINESS TURNAROUND AND GOVERNMENT POVERTY REDUCTION STRATRGIES MEET

- Sericulture as an innovation
  - Business innovation: new sourcing for an existing technology
  - Agricultural innovation: adoption of previously totally unknown(to local farmers) farming techniques and new production methods
  - New use for the mulberry tree
- Sericulture as a poverty reduction strategy
  - Sericulture as a more profitable land use for a landlocked hilly country
  - Sericulture as a new source of employment and income generation

SERICULTURE ADOPTION: OVERVIEW

- Ugandan and Kenyan experience
- Rwanda's approach: public-private partnership
- Government support
- Diffusion method: farmers co-operatives
- Vision 2020 and the 10,000 hectare objective

IMPACT EVALUATION

- Methodological challege:
  - the imputation problem
  - Counterfactual experiment

ASSESSING ECONOMIC IMPACT WITH PSM

Farmers' income Y is defined as a function of socio-economic factors.

S is an indicator function of sericulture adoption: this adoption depends on a subset *Wi* of variables that also determine income more generally

$$Y_i^s = \Psi_i^S(X_i) + \varepsilon_i^S, \qquad a = 0, 1$$

$$S_i = \phi(W_i) + \zeta_i,$$

The income impact is the expected difference between the income of the households that have adopted sericulture and what their income would have been if they had not adopted it. This is what Rosenbaum and Rubin (1983) define as the average treatment effect (ATE) what RATE is :
The average treatement effect is thus defined as

$$\alpha = E(Y_i^1 - Y_i^0).$$

METHODOLOGICAL CHALLENGE

- Imputation problem:
  - The determination of the ATE is made difficult by the fact that for each household, only one state or can be observed but not both
  - Counterfactual experiment cannot be conducted
  - Technology adoption is not a random experiment
- With a judicious specification of the income determination and innovation adoption function, an unbiased estimate of the treatment effect can be calculated if random components are assumed to be orthogonal to the observed income determinants

WHAT CAN BE OBSERVED

What is observable is the income of households that adopted sericulture and the income of households that did not adopt it. But htey are not the same households

The average income of households is thus:

$$Y_i = S_i Y_i^1 + (1 - S_i) Y_i^0 \quad S = 0, 1.$$

The expression for ATE can thus be rewritten as:

$$\alpha = P[E(Y^1 \mid S = 1) - E(Y^0 \mid S = 1)] + (1 - P).[E(Y^1 \mid S = 0) - E(Y^0 \mid S = 0)]$$

P is the probability of observing a household that adopted sericulture in the sample. The average treatment effect is thus the weighted average of the adoption effect on the two categories of households: those who have adopted sericulture (treatment group) and those who have not (control group), each weighted by its relative frequency

ASSUMPTIONS TO OVERCOME THIS METHODOLOGICAL CHALLENGE

- Random effects are orthogonal to the observed income determinants
  - The primary assumption underlying the estimation of the treatment effect is the conditional independence assumption (CIA), which assumes that the decision to adopt is random and uncorrelated with observed income once we have controlled for observed income determinants
  - The treatment effect is assumed constant and independent of the values taken by the variables (common effect)
  - Under the assumptions of conditional independence and constant effect the OLS can produce unbiased estimates of the treatment effect. The only remaining bias problem would be that the random coefficient is estimated without taking into account unobserved household-specific heterogeneity, which can lead to heteroscedasticity in the error terms

ISSUE ON THE ASSUMPTIONS

- These assumptions of conditional independence and common effects are however too restrictive and often do not hold in the real world
- In order to deal with this problem, it is necessary to relax the restrictive assumption of common effect and apply the non-parametric propensity score matching procedure **Rosenbaum and Rubin (1983).**
- As pointed out by **Heckman et al. (1997)** however, the relaxation of this assumption leads to reduced efficiency (larger standard errors) in the estimation

PROPENSITY SCORE MATCHING

- The main feature of the PSM procedure is the creation of conditions for a randomised experiment in which evaluation is restricted to local comparison between adopting and non-adopting households having otherwise similar characteristics
- Matching adopters based on observed covariates might not be feasible or could be difficult when the set of covariates are large.
- **Rosenbaum and Rubin (1983)** suggested that instead of matching along the income covariates X_i, one can match along $p(X_i)$, a single index variable that summarizes covariates. This index is known as the propensity score.
- The application of propensity score matching procedure must rely on the conditional independence assumptions, but since it compares households with similar income determinants it renders the assumption that technology adoption is uncorrelated with income more plausible.

PSM METHOD

- PSM is applied in two steps:
  - First, a probability model for the adoption of sericulture technology is estimated to calculate the probability (or propensity scores) of adoption for each observation
  - This is the propensity score that will allow us to identify similar households for matching. The basic approach in matching is to numerically search for non-adopters who have a propensity score that is very close to the propensity score of the adopters. This is based on the underlying logical assumption that households with the same or similar propensity scores should have the same distribution of, irrespective of whether they are adopters or non-adopters of the innovation
  - Similarity of households is established through the closeness of scores on the probability to adopt sericulture, conditional on observable income determinants
  - The main purpose of the propensity score estimation is to balance the observed distribution of covariates across the groups of adopters and non-adopters **(Lee, 2008).** The balancing test is thus required after matching to be sure that the differences in the covariates in the two groups in the matched sample have been eliminated (i.e. the matched comparison group can be considered a plausible counterfactual construct **(Ali and Abdulai, 2010).**

MAATCHING PROCEDURE

- In the second step, each adopter is matched with his/her "closest" non-adopter with similar propensity score values, in order to estimate the average treatment effect for the treated (ATT) (Asfaw et al., 2010)

- If there are unobserved variables that simultaneously affect the adoption decision and the outcome variables, this can give rise to a selection bias or hidden bias problem, to which matching estimators are not robust **(Rosenbaum, 2002**)

- Several matching methods have been developed to match adopters with non-adopters of similar propensity scores. Asymptotically, all matching methods should yield the same results. However, in practice, there are trade-offs in terms of bias and efficiency with each method (Caliendo and Kopeinig, 2008).

  - One of these matching procedures is the nearest neighbour method (NNM) that simply identifies for each household the "closest twin" or "nearest neighbour" in the opposite adoption status; then it computes an estimate of the technological effect as the average difference of household's income between each pair of matched households (the weights are given by the relative frequency in the sample of adopters and non-adopters, respectively)

  - A second method, the kernel-based matching (KBM) estimator, is more flexible than the former with respect to the specification of the propensity score. It follows the same steps as the nearest neighbour but the matching household is identified as the weighted average of all households in the opposite adoption status within a certain distance between the propensity scores, with weights inversely proportional to the distance

DATA ON R SERICULTURE ADOPTION IN 6 DISTRICTS

- The household survey data used for this evaluation were based on data from the 3rd round of Integrated Household Living Conditions Survey-EICV3 (Enquête Intégrale sur les Conditions de Vie des Ménages) completed in 2011
- The collected information include age, gender, marital status, household size, education level, main and secondary occupations, household income, number and size of owned and cultivated land assets, livestock ownership and sources of income
- For this study, a sample consisting of 1343 households based on EICV3 was selected for a further formal - stage random sample of villages in the targeted districts.

SERICULTURE ADOPTION DATA(CTD)

- The areas covered by our study where survey in six districts where sericulture has been introduced.
- The sampling framework is based on a multi sericulture cooperatives and individual farmers have started mulberry planting and cocoon production are located in the following districts: Nyaruguru (Southern Province), Bugesera (Eastern Province), Nyagahanga (Eastern Province), Karongi (Western Province), Nyanza (Southern Province) and Rushashi (Northern Province). Of the 1343 households inthe survey, 413 were identified as sericulture adopters.
- In this study, adopters are classified as households who planted mulberry trees and used the leaves to rear silkworms, and non-adopters are those who did not participate in any activity related to sericulture.
- The sample targeted farming households in these districts in order to maximize the chances of having enough adopters in the study.

MATCHING RESULTS

Table 2: Poverty measures for sericulture adopters and non-adopters

Poverty indicators among households in the 6 districts

Poverty measures	Adopters	Non-adopters	Difference
Headcount ratio poverty	0.49	0.56	-0.07**
Headcount ratio extreme poverty	0.07	0.23	-0.16**
Poverty gap	0.16	0.33	-0.17**
Severity gap	0.07	0.18	-0.11***
Number of observations	413	930	

*= significant at 10%**=significant at 5%, ***=significant at 1%

As defined by the Rwandan national Institute of Statistics, the poverty line is set at an annual income of FRW 64,000 in 2001 prices while extreme poverty line is at FRW 45,000

MATCHING RESULTS (CTD)

Table 3: Propensity score for sericulture adoption in the 6 districts

Logit propensity score for sericulture adoption		
Variables	Coeff	(std errors)
Average age of head of household	0.179**	-0.083
Educational achievement	0.142	-0.097
Household size	-0.076**	-0.036
Gender of head of household	-0.045	-0.037
Main occupation of head of household	0.167	-0.131
Years of farming experience	0.019*	-0.011
Marital status head of household	0.027	-0.012
Land ownership		
Average size of owned land	0.512	-0.321
Average size of land in use	0.616*	-0.358
Land productivity	-0.045	-0.023
Number of land plots owned	0.023	-0.016
Total assets owned	0.014	-0.011
Chi-square = 0.51;	p-value= 0.921	
Log-likelihood	139.821	
Number of observations	1343	

* = significant at 10%; **= significant at 5%; *** = significant at 1%

MATCHING RESULTS (CTD)

Table 3: Propensity score for sericulture adoption in the 6 districts

Logit propensity score for sericulture adoption		
Variables	Coeff	(std errors)
Association membership and access		
Membership of cooperatives	0.734***	-0.214
Membership other associations	0.141	-0.109
Access to rural infrastructure	0.017**	-0.008
Contact with extension agents	0.936***	-0.156
Access to credit	0.294**	-0.145
Previous adoption of innovation	0.714**	-0.342
Constant	2.579***	-0.564
Chi-square = 0.51;	p-value= 0.921	
Log-likelihood	139.821	
Number of observations	1343	

* = significant at 10%; **= significant at 5%; *** = significant at 1%

Table 4: NNM and KBM matching results for the 4 provinces

	Eastern Province†				Northern Province				Western Province			
	NNM[a]		KBM		NNM[a]		KBM		NNM[a]		KBM	
Variable	Coefficient	(t-value)	Coefficient	(t-value)	Coeff	(t-value)	Coefficient	(t-value)	Coefficient	(t-value)	Coefficient	(t-value)
Household income (ln)	0.259**	-2.907	0.245***	-2.916	0.274***	3.072	0.282***	-3.512	0.227***	-3.043	0.219***	-2.491
Head count poverty ratio	-0.181**	-2.841	-0.177***	-3.241	-0.175***	3.051	-0.169***	-3.631	-0.163***	-3.115	-0.173**	-2.037
Balancing property	yes		yes		yes		yes		yes		yes	
Common support	yes		yes		yes		yes		yes		yes	
Covariance matrix					Chi-square = 0.57; p-value = 0.911							
Nr of observ	1343											
Log-likelihood	-148.528											

† Southern and Eastern Provinces are Pooled;^{a}:bootstrapped, 200 replications

Significance levels : * : 10% ** : 5% *** : 1%

MATCHING RESULTS

Table 4: NNM and KBM matching results for the 4 provinces

	Eastern Province†				Northern Province				Western Province			
	NNM[a]		KBM		NNM[a]		KBM		NNM[a]		KBM	
Variable	Coefficient	(t-value)	Coefficient	(t-value)	Coeff	(t-value)	Coefficient	(t-value)	Coefficient	(t-value)	Coefficient	(t-value)
Ratio of extreme poverty	-0.123*	-1.913	-0.114**	-2.157	-0.091**	2.703	-0.114**	-2.942	-0.141*	-1.803	-0.098***	-3.232
Poverty severity	-0.064**	-2.202	-0.081**	-2.046	-0.089**	2.812	-0.076**	-3.104	-0.071**	-2.152	-0.081***	-3.011
Balancing property	yes		yes		yes		yes		yes		yes	
Common support	yes		yes		yes		yes		yes		yes	
Covariance matrix					Chi-square = 0.57; p-value = 0.911							
Nr of observ	1343											
Log-likelihood	-148.528											

BY WAY OF CONCLUSION

- Sericulture adoption has had a modest but measurable effect on income generation and poverty reduction
- the development of adequate supporting infrastructure and a sustained investment in training farmers in sericulture techniques remains a must
- Moreover, for the adoption to succeed, sustained investment in sericulture related research and university-level knowledge in both *bombyx mori* rearing and mulberry cultivation will remain necessary to avoid the failures that have plagued other African countries seeking to develop sericulture.
- Aas cautioned by **Kafle (2010),** however, it becomes difficult to evaluate the factors influencing the adoption when the proportion of adopters is either very large or very low. An evaluation based on survey data of adopting farmers at this stage unavoidably suffers from data scarcity. A larger study when the adoption has duffused further can enable more robust results and more meaningful conclusions

DISCUSSION QUESTION

- Why is sericulture, which has the potential to reduce poverty and improve land use on steep hill slopes, so slow to diffuse in Rwanda despite the supporting role that the government has undertaken?