Household Consumption Smoothing in Tanzania's Kagera Region

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Abstract

The full consumption insurance hypothesis is tested using a dataset collected in the Kagera region. The full consumption insurance hypothesis is rejected in all cases. However, all coefficients for the change (in natural logarithm) of income are small. In the CARA preference cases the coefficients for change in income were larger when we estimated them in all clusters than when we estimated them only in rural clusters. In the CRRA preference cases the coefficients for the change in natural logarithm in income are smaller when we estimate them in all clusters than when we estimate them only in rural clusters.

Keywords : Consumption smoothing; informal insurance systems; Tanzania

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1. Introduction

This paper investigates the extent to which household consumption is smoothed in Tanzania's Kagera region. In this paper, consumption smoothing means that an idiosyncratic shock to a household does not affect its consumption during any period. The full consumption insurance hypothesis is tested using a dataset collected in the Kagera region. The full consumption insurance hypothesis purports that individual or household consumption is insured against an idiosyncratic shock during any period in its community. To my knowledge, this paper is the first to explicitly investigate consumption smoothing in Tanzania.

The Kagera region is a rural area located in northwest Tanzania. A rural economy depends primarily on agricultural industry and is affected by shocks such as weather, output, price, and worker illness. As a rural economy does not possess a sufficient number of official financial institutions to manage income uncertainty caused by such shocks, rural residents might insure their consumption via unofficial manners, i.e., by lending and borrowing wealth from each other.

The full consumption insurance hypothesis is tested in this paper. It is important to analyze the risk management ability of people in developing countries when creating policies that will reduce poverty in those countries.

This paper is organized as follows. Section 2 presents the theoretical model introduced by Townsend (1994) and Kurosaki (1999) for testing full consumption insurance. Section 3 presents the estimation procedure used to test the full consumption insurance. Section 4 discusses the dataset employed in this paper. Section 5 presents the results of the test for the full consumption insurance. Section 6 concludes the paper and proposes policies.

2. Theoretical Model

What follows is a basic theoretical model for risk sharing, based on Townsend (1994) and Kurosaki (1999).

Consider a rural economy with N households. Uncertainty exists in this economy. At a period t, a state s occurs with probability π_{st}. At a period t, a household i is given income y_{ist} with probability π_{st}. At a period t, a household obtains utility $u_i = u_i(c_{ist})$ by consuming c_{ist}. We assume that $u_i' > 0$ and that $u_i'' < 0$.

Now, we consider the social planner's optimum problem.

$$\max_{\{c_{ist}\}} \sum_{i=1}^{N} \lambda_i \sum_{t=1}^{\infty} \rho_i^t \sum_s \pi_{st} u_i(c_{ist}) \tag{1}$$

s.t. $\sum_{i=1}^{N} c_{ist} \leq \sum_{i=1}^{N} y_{ist}$ for any s and any t (2)

and $c_{ist} \geq 0$ for any i, any s and any t where λ_i is a household i's Pareto-Negishi weight and ρ_i is a household i's subjective discount factor.

Assuming an interior solution, the Pareto optimum allocation is described implicitly by the first order conditions

$$\lambda_i \rho_i^t u_i'(c_{ist}) = \mu_{st} \text{ for any } i \quad (3)$$

where μ_{st} is defined by constraint (2)'s Lagrange multiplier with the state s at the period t divided by the probability π_{st}.

Equation (3) shows that each household's marginal utility weighted by λ_i is the same over all households with the state s at the period t. Hence, (3) implies that the idiosyncratic shock does not affect each household's consumption. Each household's consumption is affected by μ_{st} which means the aggregate income shock in the community studied.

We assume particular utility functions to test the necessary condition for the full consumption insurance empirically. We assume a constant absolute risk aversion (CARA) utility function and a constant relative risk aversion (CRRA) utility function.

We omit the subscript s in the following.

First, we consider the CARA utility function. The CARA utility function is given by

$$u_i(c_i) = -\tfrac{1}{A_i}\exp(-A_i c_i) \quad (4)$$

where A_i is an Arrow-Pratt coefficient of absolute risk aversion.

(2), (3), and (4) imply that

$$c_{it} = -\tfrac{1}{A_i}\ln\mu_t + \tfrac{1}{A_i}\ln\lambda_i + \tfrac{1}{A_i}t\ln\rho_i = \alpha_i\bar{c}_t + \beta_i + \gamma_i t \quad (5)$$

where $\alpha_i \equiv \tfrac{1}{A_i}\left[\tfrac{1}{N}\sum_{j=1}^{N}\left(\tfrac{1}{A_j}\right)\right]^{-1}$, (6)

$$\beta_i \equiv \tfrac{1}{A_i}\left[\ln\lambda_i - \tfrac{1}{N}\sum_{j=1}^{N}\alpha_j \ln\lambda_j\right], \quad (7)$$

$$\gamma_i \equiv \tfrac{1}{A_i}\left[\ln\rho_i - \tfrac{1}{N}\sum_{j=1}^{N}\alpha_j \ln\rho_j\right] \quad (8)$$

and $\bar{c}_t$ is average consumption in a community at a period t.

If $\rho_i = \rho$ for any i, we have $\gamma_i = 0$. Then the time trend does not affect the consumption level. Equation (7) implies that a household with a higher λ_i is allocated a higher consumption level.

If a household is more impatient (smaller ρ_i), γ_i is smaller. Then the household i's consumption level would be lower.

In the same manner, we have

$$c_{i,t+1} = -\tfrac{1}{A_i}\ln\mu_{t+1} + \tfrac{1}{A_i}\ln\lambda_i + \tfrac{1}{A_i}(t+1)\ln\rho_i = \alpha_i\bar{c}_{t+1} + \beta_i + \gamma_i(t+1) \tag{9}$$

By using (5) and (9), we have

$$c_{i,t+1} - c_{it} = -\tfrac{1}{A_i}\left[\ln\mu_{t+1} - \ln\mu_t - \ln\rho_i\right] = \alpha_i(\bar{c}_{t+1} - \bar{c}_t) + \gamma_i. \tag{10}$$

Equation (10) shows that each household's specific effect is included in a coefficient (α_i) for a difference between $\bar{c}_{t+1}$ and $\bar{c}_t$, and an intercept (γ_i).

Second, we consider the CRRA utility function. The CRRA utility function is given by

$$u_i(c_i) = \tfrac{1}{1-R_i}c_i^{1-R_i} \tag{11}$$

where R_i is an Arrow-Pratt coefficient of relative risk aversion.

In the same manner as the CARA utility function case, we have

$$\ln c_{it} = -\tfrac{1}{R_i}\ln\mu_t + \tfrac{1}{R_i}\ln\lambda_i + \tfrac{1}{R_i}t\ln\rho_i = \alpha_i'\overline{\ln c_t} + \beta_i' + \gamma_i't \tag{12}$$

where
$$\alpha_i' \equiv \tfrac{1}{R_i}\left[\tfrac{1}{N}\sum_{j=1}^{N}\left(\tfrac{1}{R_j}\right)\right]^{-1}, \tag{13}$$

$$\beta_i' \equiv \tfrac{1}{R_i}\left[\ln\lambda_i - \tfrac{1}{N}\sum_{j=1}^{N}\alpha_j'\ln\lambda_j\right], \tag{14}$$

$$\gamma_i' \equiv \tfrac{1}{R_i}\left[\ln\rho_i - \tfrac{1}{N}\sum_{j=1}^{N}\alpha_j'\ln\rho_j\right] \tag{15}$$

and $\overline{\ln c_t}$ is an average value of the logarithm of consumption in a community at a period t.

In the same manner as in the CARA utility function case, we have

$$\ln c_{i,t+1} - \ln c_{it} = -\tfrac{1}{R_i}\left[\ln\mu_{t+1} - \ln\mu_t - \ln\rho_i\right] = \alpha_i'\left(\overline{\ln c_{t+1}} - \overline{\ln c_t}\right) + \gamma_i'. \tag{16}$$

Equation (16) shows that each household's specific effect is included in a coefficient (α_i') for a difference between $\overline{\ln c_{t+1}}$ and $\overline{\ln c_t}$, and an intercept (γ_i').

3. Estimation Procedure

Townsend (1994) estimates

$$\Delta c_{it} = a_0 + a_1\Delta\bar{c}_t + a_2\Delta y_{it} + \Delta u_{it} \tag{17}$$

where $\Delta c_{it} \equiv c_{it} - c_{i,t-1}$, $\Delta\bar{c}_t \equiv \bar{c}_t - \bar{c}_{t-1}$, $\Delta y_{it} \equiv y_{it} - y_{i,t-1}$ and $\Delta u_{it} \equiv u_{it} - u_{i,t-1}$ using the ICRISAT Indian dataset. This estimation equation is for a CARA utility function case. Through a detailed calculation, Townsend shows that $a_1 = 1$.

As shown by Kurosaki and Sawada (1999), Δy_{it} shows an idiosyncratic income shock since making a first order difference for y_{it} leads to no household fixed effect (that is, no permanent income part) in Δy_{it} and since a change for an average consumption in a community, $\Delta \bar{c}_t$, controls for a common shock in a community.

Therefore, the full consumption insurance hypothesis is tested by testing the null hypothesis that $H_0 : a_2 = 0$.

Ravallion and Chaudhuri (1997) modified the Townsend's (1994) estimation procedure. They proposed an estimation equation

$$\Delta c_{it} = \sum_t \delta_t D_t + b\Delta y_{it} + \Delta u_{it} \tag{18}$$

to modify estimation equation (17). D_t is a time dummy. The estimated coefficient $\hat{\delta}_t$ shows an aggregate shock in a community at a period t. Hence the estimated coefficient $\hat{b}$ shows only the effect of an idiosyncratic income change. In estimating the equation (17), since the measurement error in $\Delta \bar{c}_t$ and the measurement error in Δy_{it} might correlate positively, an estimated a_2 would be smaller if a real $\hat{a}_2$ is positive.

We employ an estimation equation (18) and add some terms to (18). In the CARA utility function case, we estimate

$$\Delta c_{it} = \beta_0 + \sum_{t=2}^{4} \beta_{1t} D_t + \beta_2 \Delta y_{it} + \sum_l \beta_3 D_l + \beta_4 D_{ur} + v_{it} \tag{19}$$

$(i = 1, \cdots, N, t = 2,3,4)$ where D_l is a location (cluster) dummy, D_{ur} is an urban dummy, and v_{it} is a disturbance term.

And in the CRRA utility function case, we estimate

$$\Delta \ln c_{it} = \beta_0' + \sum_{t=2}^{4} \beta_{1t}' D_t + \beta_2' \Delta \ln y_{it} + \sum_l \beta_3' D_l + \beta_4' D_{ur} + v_{it}' \tag{20}$$

$(i = 1, \cdots, N, t = 2,3,4)$ where $\Delta \ln c_{it} \equiv \ln c_{it} - \ln c_{i,t-1}$, $\Delta \ln y_{it} \equiv \ln y_{it} - \ln y_{i,t-1}$, and v_{it}' is a disturbance term.

We estimate a model with AR (1) in disturbance terms if a hypothesis of no autocorrelation of Order 1 is rejected.

An instrumental variables (IV) method is used for all estimations in section 5 because (1) we might have measurement errors in consumption and income and (2) those measurement errors induce a downward bias in an estimated coefficient for an income change if those measurement errors correlate positively. The per capita employment income change, wave dummies, cluster dummies, and urban dummy are instrumental variables when we estimate in all clusters. The per capita employment income change, wave dummies, and cluster dummies are instrumental variables when we estimate only in rural clusters. Those variables are used as instrumental variables since measurement errors of those variables and consumption do not correlate.

In the empirical results tables, a wave means a cycle during which the Tanzania's Kagera Health and Development Survey took place. We do not have a time dummy for $t = 2$ when we estimate Equations (19) or (20) since Wave 2 is a base period. We do not include variables for Cluster 45 and Cluster 47 when we estimate Equations (19) or (20) since we do not know whether those clusters are urban or rural. And we do not include variables for Cluster 32 when we estimate Equations (19) or (20) since there are too many outlier values for variables of Cluster 32.

4. Data and Summary Statistics

(1) About the Dataset

Tanzania's Kagera Health and Development Survey (KHDS) dataset was used for this study. The KHDS interviewed more than 800 households from nearly 50 communities in Kagera's districts. Households, community leaders, health facilities, schools, and market vendors were asked questions at approximately six-month intervals over four survey periods. The KHDS questionnaires were adopted from the World Bank's Living Standards Measurement Study (LSMS) questionnaires.

(2) Definitions of Variables

Definitions for variables in Table 1 are introduced.

Real per capita income is in Tanzania Shillings and is a real per capita value for the sum of six components (employment income, income from agricultural self-employment, non-farm self-employment income, income from rent, transfer income from individuals and organizations, and other non-labor income).

Real per capita total consumption is in Tanzania Shillings and is a real per capita value for a sum of food consumption and non-food consumption. Food consumption has four components (purchased seasonal food, purchased non-seasonal food, valuation of home-produced seasonal food, and valuation of home-produced non-seasonal food). Non-food consumption has seven components (education, miscellaneous non-food expenditures, health, funerals, utilities, wage-in-kind, and remittances). Real per capita food consumption is in Tanzania Shillings and is a real per capita value for food consumption.

(3) Interpretation of Table 1 Figures

Note that each mean value in Table 1 is a value for half a year. The mean real per capita consumption (23461.94 Tanzania Shilling) is approximately 50% of the mean real per capita income (46731.71 Tanzania Shillings). Some households have negative real per capita incomes, as shown in Table 1.

The mean real per capita food consumption is 16% of the mean real per capita income and 32% of the mean real per capita consumption. Hence the Engel coefficient is 0.32, which is not considered to be high.

5. Empirical Result

In the analysis below:

Method 1 refers to a case in which an individual has a CARA type preference. Hence, we have a real per capita total income change as an independent variable in an estimation equation. The dependent variable in the estimation equation is a real per capita total consumption change.

Method 2 refers to a case in which an individual has a CARA type preference. Hence, we have a real per capita total income change as an independent variable in an estimation equation. The dependent variable in the estimation equation is a real per capita food consumption change.

Method 3 refers to a case in which an individual has a CRRA type preference. Hence, we have a change in natural logarithm for a real per capita total income as an independent variable in an estimation equation. The dependent variable in the estimation equation is a change in natural logarithm for real per capita total consumption.

Method 4 refers to a case in which an individual has a CRRA type preference. Hence, we have a change in natural logarithm for a real per capita total income as an independent variable in an estimation equation. The dependent variable in the estimation equation is a change in natural logarithm for real per capita food consumption.

It may be suggested that a term of four periods is too short to conduct a thorough empirical analysis. However, Kurosaki and Sawada (1999) conducted an empirical analysis using a dataset collected over only three years in Pakistan. Thus, the term of the dataset used in this paper is sufficient for conducting an empirical analysis.

OLS estimation results are reported in the Appendix as a benchmark even though the OLS method is rejected in a panel analysis in this chapter.

(1) Regression for All Households in All Clusters

The empirical results of Methods 1-4 in estimating in all clusters are shown in Tables 2-5.

In all four cases, the coefficients for the change (in natural logarithm) of income are significant and positive.

In both the CARA utility function cases and the CRRA utility function cases, the estimated coefficients for the change (in natural logarithm) of income are smaller when the dependent variables are the change (in natural logarithm) of food consumption rather than when the dependent variables are the change (in natural logarithm) of total consumption. Therefore, food consumption might be better insured than total consumption if we regard the Kagera region as a unit for consumption insurance, although the full consumption insurance hypothesis is rejected with a significance level of 1% in all four methods in this subsection. Hence, income change might affect non-food consumption more.

The four cases are analyzed below.

(1.1) CARA Utility Function Cases

(1.1.1) Dependent variable is total consumption change

We accept a pooling model in the panel analysis. Further, no autocorrelation of Order 1 in disturbance terms is rejected. Hence, we also estimate coefficients in the pooling model with AR (1) in disturbance terms. The coefficient for the real per capita income change in the pooling model without AR (1) in disturbance terms is almost the same as the coefficient for the real per capita income change in the pooling model with AR (1) in disturbance terms.

Using the IV method, we achieved the same estimated coefficient for a real per capita income change as the estimated coefficient for a real per capita income change in a pooling model. The IV method is rejected with a significance level of 5% by a Hausman test.

The full consumption insurance hypothesis is rejected with a significance level of 1% for (1) the coefficient for the real per capita income change in the pooling model without AR (1) in disturbance terms, (2) the coefficient for the real per capita income change in the pooling model with AR (1) in disturbance terms, and (3) the coefficient for the real per capita income change in the pooling model with the IV method. Hence, an idiosyncratic shock affects each household's consumption.

However, the coefficients for a real per capita income change in the above three cases are very small. Therefore, the total consumption might be well-insured if we regard the Kagera region as a unit for consumption insurance.

(1.1.2) Dependent variable is food consumption change

We accept a random effect model in the panel analysis. Further, no autocorrelation of Order 1 in disturbance terms is rejected. Hence, we also estimate coefficients in a random effect model with AR (1) in disturbance terms. The coefficient for the real per capita income change in the random effect model without AR (1) in disturbance terms is almost the same as the coefficient for the real per capita income change in the random effect model with AR (1) in disturbance terms.

In a random effect model with the IV method, we achieved the same estimated coefficient for a real per capita income change as the estimated coefficient for a real per capita income change in a random effect model without the IV method and OLS. The IV method is accepted by a Hausman test.

The full consumption insurance hypothesis is rejected with a significance level of 1% for the following: (1) the coefficient for the real per capita income change in the random effect model without AR (1) in disturbance terms, (2) the coefficient for the real per capita income change in the random effect model with AR (1) in disturbance terms, and (3) the coefficient for the real per capita income change in the random effect model with the IV method. Hence, an idiosyncratic shock affects each household's consumption.

However, all of the coefficient for the real per capita income change in the random effect model without AR (1) in disturbance terms, the coefficient for the real per capita income change in the random effect model with AR (1) in disturbance terms, and the coefficient for the real per capita income change in the random effect model with IV method are very small. Therefore, food consumption might be well-insured if we regard the Kagera region as a unit for consumption insurance.

(1.2) CRRA Utility Function Cases

<u>Dependent variable is a change in natural logarithm of total consumption or a change in natural logarithm of food consumption</u>

We accept a random effect model in the panel analysis. Furthermore, no autocorrelation of Order 1 in disturbance terms is rejected. Hence, we also estimate coefficients in the random effect model with AR (1) in disturbance terms. The coefficient for the change in natural logarithm of the real per capita income in the random effect model without AR (1) in disturbance terms is almost the same as the coefficient for the change in natural logarithm of the real per capita income in the random effect model with AR (1) in disturbance terms.

In a random effect model using the IV method, we achieved the same estimated coefficient for the change in natural logarithm of the real per capita income as the estimated coefficient for the change in natural logarithm of the real per capita income in a random effect model without the IV method and OLS.

The full consumption insurance hypothesis is rejected with a significance level of 1% for the following: (1) the coefficient for the change in natural logarithm of the real per capita income in the random effect model without AR (1) in disturbance terms, (2) the coefficient for the change in natural logarithm of the real per capita income in the random effect model with AR (1) in disturbance terms, and (3) the coefficient for the change in natural logarithm of the real per capita income in the random effect model with the IV method. Hence, an idiosyncratic shock affects each household's consumption.

(2) Regression for All Households in All Rural Clusters

The empirical results of Methods 1-4 in estimating only in rural clusters are shown in Tables 6-9.

In all four cases, the coefficients for the change (in natural logarithm) of income are significant and positive.

In the CARA utility function cases, the estimated coefficient for the change in income is smaller when the dependent variable is the change in food consumption than when the dependent variable is the change in total consumption. Therefore, food consumption might be better insured compared to total consumption if we regard the rural Kagera region as a unit for consumption insurance and if rural Kagera region residents have the CARA type preference. Hence, income change might affect non-food consumption more. However, the full consumption insurance hypothesis is rejected with a significance level of 1% in both methods in the CARA preference.

It is estimated that both total consumption and food consumption are better insured in the rural Kagera region compared to the entire Kagera region. This is because stronger social ties exist in the rural Kagera region compared to the urban Kagera region, and therefore rural Kagera region residents are more inclined to help each other during times of difficulty. Thus, we investigated whether both total consumption and food consumption are better insured in the rural Kagera region compared to the entire Kagera region.

In CARA preference cases, the coefficients for change of income are bigger when estimated in all clusters than when estimated only in rural clusters. However, in the CRRA preference cases the coefficients for the change in natural logarithm of income were smaller when estimated in all clusters than when estimated only in rural clusters.

The four methods are analyzed below.

(2.1) CARA Utility Function Cases

<u>Dependent variable is total consumption or food consumption</u>

We accept a random effect model in the panel analysis. Furthermore, the hypothesis of no autocorrelation of Order 1 in a disturbance terms is rejected. Hence, we also estimate coefficients in the random effect model with AR (1) in disturbance terms. The coefficient for the real per capita income change in the random effect model without AR (1) in disturbance terms is almost the same as the coefficient for the real per capita income change in the random effect model with AR (1) in disturbance terms.

In a random effect model with the IV method, we achieved the same estimated coefficient for a real per capita income change as the estimated coefficient for a real per capita income change in a random effect model without the IV method and OLS. The IV method is accepted by a Hausman test when a dependent variable is total consumption.

The full consumption insurance hypothesis is rejected with a significance level of 1% for the following: (1) the coefficient for the real per capita income change in the random effect model without AR (1) in disturbance terms, (2) the coefficient for the real per capita income change in the random effect model with AR (1) in disturbance terms, and (3) the coefficient for the real per capita income change in the random effect model with the IV method. Hence, an idiosyncratic shock affects each household's consumption.

However, all of the coefficient for the real per capita income change in the random effect model without AR (1) in disturbance terms, the coefficient for the real per capita income change in the random effect model with AR (1) in disturbance terms, and the coefficient for the real per capita income change in the random effect model with the IV method are very small. Therefore, total consumption and food consumption might be well-insured if we regard the rural Kagera region as a unit for consumption insurance.

(2.2) CRRA Utility Function Cases

(2.2.1) Dependent variable is a change in natural logarithm of total consumption

We accept a pooling model in the panel analysis. Further, no autocorrelation of Order 1 in disturbance terms is rejected. Hence, we estimate coefficients in the pooling model with AR (1) in disturbance terms. The coefficient for the change in natural logarithm of the real per capita income in the pooling model without AR (1) in disturbance terms is almost the same as the coefficient for the change in natural logarithm of the real per capita income in the pooling model with AR (1) in disturbance terms.

Using the IV method, we achieved the same estimated coefficient for a change in natural logarithm of the real per capita income as the estimated coefficient for a change in natural logarithm of the real per capita income in a pooling model.

The full consumption insurance hypothesis is rejected with a significance level of 1% for (1) the coefficient for the change in natural logarithm of the real per capita income in the pooling model without AR (1) in disturbance terms, (2) the coefficient for the change in natural logarithm of the real per capita income in the pooling model with AR (1) in disturbance terms, and (3) the coefficient for a change in natural logarithm of the real per capita income in the pooling model with the IV method. Hence, an idiosyncratic shock affects each household's consumption.

(2.2.2) Dependent variable is a change in natural logarithm of food consumption

We accept a random effect model in the panel analysis. Further, no autocorrelation of Order 1 in disturbance terms is rejected. Hence we also estimate coefficients in the random effect model with AR (1) in disturbance terms. The coefficient for the change in logarithm of the real per capita income in the random effect model without AR (1) in disturbance terms is almost the same as the coefficient for the change in logarithm of the real per capita income in the random effect model with AR (1) in disturbance terms.

In a random effect model using the IV method, we achieved the same estimated coefficient for the change in natural logarithm of the real per capita income as the estimated coefficient for the change in natural logarithm of the real per capita income in a random effect model without the IV method and OLS.

The full consumption insurance hypothesis is rejected with a significance level of 1% for the following: (1) the coefficient for the change in natural logarithm of the real per capita income in the random effect model without AR (1) in disturbance terms, (2) the coefficient for the change in natural logarithm of the real per capita income in the random effect model with AR (1) in disturbance terms, and (3) the coefficient for the change in natural logarithm of the real per capita income in the random effect model with the IV method. Hence, an idiosyncratic shock affects each household's consumption.

6. Conclusion

This paper presents an empirical analysis of consumption smoothing behavior of households in Tanzania's Kagera region. The following results were obtained.

First, the full consumption insurance hypothesis is rejected in all cases investigated. However, all coefficients for the change (in natural logarithm) of income are small. Further, those coefficients are very small for Kagera region residents with the CARA type preference. Hence, we can assume that total consumption and food consumption are well-insured in Tanzania's Kagera region if residents have the CARA preference.

Second, in the CARA preference cases the coefficients for change in income were larger when we estimated them in all clusters than when we estimated them only in rural clusters. However, in the CRRA preference cases, the coefficients for the change in natural logarithm in income are smaller when we estimate them in all clusters than when we estimate them only in rural clusters. Hence, we cannot know whether total consumption or food consumption is better insured in the rural Kagera region than in the urban Kagera region.

The dataset used for this paper indicates only whether a cluster is urban or rural. Some factors which might affect the formation of an informal consumption insurance system have not been taken into account. For example, physical distance between clusters might decide whether residents in those clusters form an informal consumption insurance system. Further, whether people have the same ethnicity might determine whether they form informal consumption insurance systems. Hence, factors which might affect the formation of informal consumption insurance systems should be incorporated into future research.

Some policies can be implemented to help Kagera residents to smooth their consumption. For example, the government can invest in agricultural infrastructure. Further, the government can build an insurance system for weather risk in agriculture. The government can build a school to obtain agricultural skills.

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Appendix

Table1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Real per capita income (TS)	46731.71	60767.86	-128332	1452822
Real per capita total consumption (TS)	23461.94	41895.52	325	971027.9
Log real per capita total consumption (TS)	9.5916	0.8942	5.78383	13.78611
Real per capita food consumption (TS)	7619.574	13148.07	28.57143	230355.3
Log real per capita food consumption (TS)	8.2061	1.24215	3.35241	12.34738
Real per capita total stock (TS)	194807.6	1208139	-597.345	56000000
Real per capita financial stock (TS)	3752.483	49121.92	-743750	1560585
Real per capita physical stock (TS)	191055.1	1198323	0	56000000
Real per capita land value (TS)	85666.91	286225.2	0	11500000
Household size (Number)	5.8219	2.92807	1	19
Household head age (Years Old)	50.30015	16.81531	3	98
Household head sex: = 1 if male, female = 0	0.72419	0.447	0	1
Household head's schooling: = 1 if primary, other = 0	0.68695	0.46382	0	1
Household head's schooling: = 1 if secondary, other = 0	0.03097	0.17328	0	1
Household head's schooling: = 1 if advanced secondary, other = 0	0	0	0	0
Household head's schooling: = 1 if university, other = 0	0.00479	0.06908	0	1
Observations: 2696				

Source: Tanzania's Kagera Health and Development Survey (1991-1994)
TS means Tanzania Shilling.

Table 2: Estimation Results (All Clusters, Method 1)

	OLS	GLS	OLS(IV)	OLS(AR(1))
Change of income	0.168*** (0.049)	0.139*** (0.005)	0.168*** (0.013)	0.178*** (0.048)
NOB	2022	2022	2022	2022
R-squared	0.151		0.151	0.155
F stat	0.43			
Hausman stat (d.f.)	6.31**		70.95(47)**	(rho=.072)
Breusch Pagan test	115.72***			(DW stat (transformed)=1.975)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

Table 3: Estimation Results (All Clusters, Method 2)

	OLS	RE	RE(IV)	RE(AR(1))
Change of income	0.037*** (0.007)	0.037*** (0.004)	0.037*** (0.004)	0.037*** (0.004)
NOB	2022	2022	2022	2022
R-squared	0.201	overall=0.201	overall=0.201	overall=0.201
F stat		0.61		
Hausman stat (d.f.)		3.01	0.00(2)	(rho=.016)
Breusch Pagan test		45.83***		(Modified Bhargava et al. Durbin-Watson = 1.967)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

Table 4: Estimation Results (All Clusters, Method 3)

	OLS	RE	RE(IV)	RE(AR(1))
Change of log of income	0.256*** (0.019)	0.256*** (0.018)	0.256*** (0.018)	0.254*** (0.018)
NOB	2022	2022	2022	2022
R-squared	0.362	overall=0.362	overall=0.362	overall=0.362
F stat		0.28		
Hausman stat (d.f.)		3.72	-1399.44(3)	(rho=-.088)
Breusch Pagan test		198.13***		(Modified Bhargava et al. Durbin-Watson = 2.176)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

Table 5: Estimation Results (All Clusters, Method 4)

	OLS	RE	RE(IV)	RE(AR(1))
Change of log of income	0.296*** (0.032)	0.296*** (0.029)	0.296*** (0.029)	0.294*** (0.029)
NOB	2022	2022	2022	2022
R-squared	0.237	overall=0.238	overall=0.238	overall=0.237
F stat		0.27		
Hausman stat (d.f.)		2.86	-1499.19(3)	(rho=-.095)
Breusch Pagan test		212.11***		(Modified Bhargava et al. Durbin-Watson = 2.190)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

Table 6: Estimation Results (Rural Clusters, Method 1)

	OLS	RE	RE(IV)	RE(AR(1))
Change of income	0.137*** (0.048)	0.137*** (0.015)	0.137*** (0.015)	0.154*** (0.015)
NOB	1662	1662	1662	1662
R-squared	0.106	overall = 0.1056	overall = 0.1056	overall = 0.1051
F stat		0.28		
Hausman stat (d.f.)		4.40	0.00 (2)	(rho=-.104)
Breusch Pagan test		169.72***		(Modified Durbin-Watson = 2.195)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

Table 7: Estimation Results (Rural Clusters, Method 2)

	OLS	RE	RE(IV)	RE(AR(1))
Change of income	0.034*** (0.009)	0.034*** (0.003)	0.034*** (0.003)	0.034*** (0.003)
NOB	1662	1662	1662	1662
R-squared	0.227	overall = 0.2270	overall = 0.2270	overall = 0.2269
F stat		0.69		
Hausman stat (d.f.)		0.46	-0.00 (2)	(rho= .046)
Breusch Pagan test		22.84***		(Modified Bhargava et al. Durbin-Watson = 1.907)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

Table 8: Estimation Results (Rural Clusters, Method 3)

	OLS	OLS(IV)	OLS(AR(1))
Change of log of income	0.267*** (0.022)	0.267*** (0.020)	0.266*** (0.022)
NOB	1662	1662	1662
R-squared	0.373	0.373	0.373
F stat	0.27		
Hausman stat (d.f.)	7.09 **	-0.00 (41)	(rho= .031)
Breusch Pagan test	173.36***		(D-W statistic (transformed) = 1.969)
	Robust standard errors in parentheses	Standard errors in parentheses	Robust standard errors in parentheses

Table 9: Estimation Results (Rural Clusters, Method 4)

	OLS	RE	RE(IV)	RE(AR(1))
Change of log of income	0.343*** (0.036)	0.343*** (0.033)	0.343*** (0.033)	0.342*** (0.034)
NOB	1662	1662	1662	1662
R-squared	0.256	overall = 0.256	overall = 0.256	overall = 0.256
F stat		0.25		
Hausman stat (d.f.)		3.67	-0.00 (41)	(rho=-.100)
Breusch Pagan test		183.41***		(Modified Bhargava et al. Durbin-Watson = 2.200)
	Robust standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses	Standard errors in parentheses

I do not report all of the estimation results.
In the tables above: * significant at 10%; ** significant at 5%; *** significant at 1%;
F stat to test whether a pooling model is preferred to a fixed effect model or not; Hausman stat to test whether a fixed effect model is preferred to a random effect model or to test whether the IV method is accepted or not; the rho values shown in Hausman stat rows due to space limits in estimating models with AR(1) in disturbance terms; the DW stat (transformed), the Modified Bhargava et al. Durbin-Watson stat, and the Modified Durbin-Watson stat shown in Breusch Pagan test rows due to space limits in estimating models with AR(1) in disturbance terms.