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Self-Production, Friction, and Risk Sharing against Disasters: Evidence from a developing country

SAWADA Yasuyuki
RIETI

NAKATA Hiroyuki
University of Essex

KOTERA Tomoaki
RIETI

Research Institute of Economy, Trade & Industry, IAA
The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

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**Self-Production, Friction, and Risk Sharing against Disasters:
Evidence from a developing country***

Yasuyuki Sawada**
Faculty of Economics
University of Tokyo
and RIETI

Hiroyuki Nakata
Essex Business School
University of Essex

Tomoaki Kotera
Graduate School of Economics
University of Tokyo
and RIETI

Abstract

This paper uses a unique household data set collected in Vietnam to empirically test the necessary conditions for an extended version of the consumption risk-sharing hypothesis. The test explicitly incorporates self-production and uses natural disasters such as avian influenza, droughts, and floods to identify the effectiveness of market and non-market risk-sharing mechanisms. With these additional treatments, full risk sharing cannot be rejected, which suggests the presence of omitted variable bias in existing studies that reject full risk sharing. We also find that credit constraints have a significant impact, although limited commitment is not necessarily serious.

Keywords: consumption risk sharing; self-production; credit constraints; and limited commitments.

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* Corresponding author. Mailing address: Faculty of Economics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. Tel.: +81 3 5841 5572; Fax: +81 3 5841 5521. E-mail address: sawada@e.u-tokyo.ac.jp

1. Introduction

In the past 15 years, there has been remarkable progress in formulating and testing full consumption risk sharing (Townsend, 1987; Mace, 1991; Cochrane, 1991; Townsend, 1994; Udry, 1994; Hayashi, Altonji, and Kotlikoff, 1996; Ligon, 1998; Dercon, Stefan, and Pramila Krishnan, 2000; Ogaki and Zhang, 2001; Murgai et al., 2002; Fafchamps and Lund, 2003; Dubois et al., 2008; Ligon, 2008; Kinnan, 2010; Laczo, 2010). According to the canonical model of consumption risk sharing, idiosyncratic changes in household income should be absorbed by all other members within the same insurance network when the market is complete. Thus, when aggregate shocks are controlled for, idiosyncratic income shocks should not affect consumption when risk sharing is efficient. Existing studies on the full risk-sharing hypothesis typically use changes in household income, employment status, and health status from multipurpose household panel survey data as a proxy for idiosyncratic shock variables.

Because tests of full risk sharing using data from developing countries tend to reject this hypothesis, researchers have elaborated on models incorporating various sources of friction to account for the partial risk sharing that is evident in the data (Ligon, 2008). Such friction includes limited commitment constraints and moral hazard under asymmetric information. Ligon (1998) uses panel data from India to test a moral hazard–constrained insurance model against the canonical full insurance and permanent income models. Dubois et al. (2008) use Pakistani household panel data to develop and test a model with limited commitment and incomplete formal contracts. Using panel data from rural Thailand to construct models of limited commitment, moral hazard, and hidden income to explain the incomplete nature of informal insurance, Kinnan (2010) finds that the predictions of the hidden income model are supported by the data.

An alternative strategy for explaining the lack of full consumption risk sharing is to mitigate estimation biases arising from various econometric problems (Ravallion and Chaudhuri, 1997; Ogaki and Zhang, 2001).[1] By relaxing assumptions on the functional form of utility, Ogaki and Zhang (2001) find evidence in support of the full risk-sharing hypothesis at the village level. However, they replicate the results of previous research, that is, the full risk-sharing hypothesis is rejected with a constant relative risk aversion utility, a utility that is widely used in the literature. Their results suggest that errors due to econometric specification are not negligible.

In the present paper, we use a unique data set collected in Vietnam to make three main contributions to the literature. First, we mitigate a possibly important source of specification error: a failure to distinguish purchased consumption from self-produced consumption. More specifically, we apply Lewis's (1996) framework, which investigates international risk sharing with non-tradable goods, in the context of a village economy. Based on this framework, the canonical test of consumption risk sharing is likely to suffer from omitted variable bias. The direction of the bias is positive if income changes and changes in self-production are positively correlated. To implement our framework empirically, we use a unique data set from Vietnam that explicitly distinguishes purchased consumption from self-production.

Second, we use information about natural disasters as sources of exogenous variations to test the consumption risk-sharing hypothesis. Existing studies on risk sharing typically use income changes as idiosyncratic shock variables to test the full

[1] Yet, Ravallion and Chaudhuri (1997) found that the existing studies may involve bias toward the null hypothesis of full-insurance.

consumption risk-sharing hypothesis.[2] However, these variables are not necessarily exogenous to households, resulting in possible estimation biases arising from endogeneity, measurement error, and/or problems with private information (Ravallion and Chaudhuri, 1997; Ligon, 1998, 2008). Natural disasters provide for an exceptionally clean experimental situation in which one can test whether households are able to insure for at least three reasons. First, natural disasters are intrinsically exogenous and cannot be affected by households. Second, natural disasters can cause large enough losses that the noise-to-signal ratios in the disaster-related shock variables are significantly small and the data are less susceptible to attenuation bias arising from measurement error. Third, whereas the shock variables in existing studies are likely to be private information (e.g., income), losses caused by natural disasters are typically large enough to be visible and easily verifiable. Hence, the assumption of perfect information is less problematic. Because Vietnam has experienced a variety of natural disasters and epidemics, such as avian influenza, typhoons, floods, and droughts, it provides ample data related to natural disasters to be used in empirical analyses.[3]

Finally, in order to explore the reasons behind the acceptance of the full consumption risk-sharing hypothesis, we incorporate two sources of friction, that is, limited credit access and limited commitment. Unlike existing studies such as Kinnan (2010) and Laczo (2010), our strategy is to use direct information on commitment

[2] Strictly speaking, the term *full* risk sharing is not precise, since the risk concerning consumption of home produced goods is not shared in our model below. However, we use the term *full* risk sharing by following the convention in the literature.

[3] United Nations International Strategy for Disaster Reduction (2009) categorized countries in the world into 5 groups according to their vulnerability and resilience to disaster loss and their developmental limitations, particularly their capacity to benefit from international trade. Vietnam is categorized as a member of Group 4, that is, countries that are highly vulnerable economically to natural hazards.

constraints as well as credit constraints.

With an explicit consideration of self-production and the use of natural disaster shock as an instrumental variable for income changes, we find that the full consumption risk-sharing hypothesis cannot be rejected. Our results suggest that the results of the previous studies, which have tended to reject the full risk-sharing hypothesis, involve omitted variable bias arising from self-production. This bias could be particularly serious in village economies, because self-production may make up a considerable amount of total consumption.

This paper is organized as follows. In Section 2, we present the theoretical and econometric framework for our analysis. In Section 3, we explain the survey data, and in Section 4, we present the empirical results. In Section 5, we present the results based on empirical models with credit access or limited commitment constraints. This is followed by concluding remarks in Section 6.

2. Theoretical and Econometric Framework

In this section, we explain the theoretical and econometric frameworks that are used in testing the full risk-sharing hypothesis in this paper. We first explain the theoretical framework, followed by the econometric framework.

In the standard framework, full consumption risk sharing can be characterized as the solution to a benevolent social planner's problem that maximizes the weighted sum of people's lifetime utilities given social resource constraints (Mace, 1991; Cochrane, 1991; Townsend, 1004). In addition, we follow an approach by Lewis (1996) that incorporates the consumption of non-tradable goods in testing the international consumption risk-sharing hypothesis. An analogous extension that separates purchased consumption and self-production is crucial in our village setting, because consumption of self-produced farm products accounts for a large portion of total consumption. As will be explained below, ignoring the consumption of self-produced goods (or non-traded goods) may lead to omitted variable bias.

Consider an economy, which can be a village or a district, that is composed of N infinitely lived households, each facing serially independent income draws. Assume also that no storage is possible, which rules out the possibility of self-insurance. While we relegate the justification for the formulation in the Appendix, here we set up a social planner's problem for an economy with J infinitely lived households with consumption of self-produced goods that provides conditions for full consumption risk sharing. The problem is analogous to the one in Lewis (1996), in which a distinction between tradable and non-tradable goods is present:[4]

(1)
$$\begin{aligned} \max_{\{c_j^T(s_t),\, c_j^N(s_t)\}_{j,s_t}} \quad & \sum_{j=1}^{J} \lambda_j \sum_{t=0}^{\infty} \left(\frac{1}{1+\delta} \right)^t \sum_{s_t} \pi(s_t) u_j \left[c_j^T(s_t),\ c_j^N(s_t) \right] \\ \text{s.t.} \quad & \sum_{j=1}^{J} c_j^T(s_t) \le \sum_{j=1}^{J} y_j^T(s_t),\ \forall s_t, \\ & c_j^N(s_t) \le y_j^N(s_t),\ \forall j,\ s_t, \end{aligned}$$

where λ_j is the Pareto-Negishi weight attached to household j; t denotes time; $\pi(s_t)$ is the probability of state s_t in time t; δ is a subjective discount rate; u_j is j's utility function; $c^T{}_j(s_t)$ and $c^N{}_j(s_t)$ are j's purchased consumption (or *tradables*) and consumption of

4 In the context of agricultural household models, de Janvry, Fafchamps, and Sadoulet (1991) refer to self-production as non-tradables.

self-produced goods (or *non-tradables*) in state s_t, respectively; $y^T_j(s_t)$ is j's tradable portion of the initial endowment; and $y^N_j(s_t)$ is j's self-produced or non-tradable portion of the initial endowment.

The first-order conditions of this problem with respect to purchased consumption are as follows:

$$\left(\frac{1}{1+\delta}\right)^t \lambda_j \, \pi(s_t) \frac{\partial u\left[c_j^T(s_t), c_j^N(s_t)\right]}{\partial c_j^T(s_t)} = \mu(s_t),$$

where $\mu(s_t)$ is the Lagrangian multiplier associated with the purchased consumption constraint in problem (1). Following Baxter and Jermann (1999) and Lewis (1996), a log-linearization of these first-order conditions gives the following testable equation:

(2) $$\Delta \ln c^T_{it} = \alpha + \beta_1 \Delta \ln c^N_{it} + \beta_Z \Delta \ln y_{it} + u_{it},$$

where Δ denotes the first-order difference (e.g. $\Delta \ln c^T_{it} = \ln c^T_{it} - \ln c^T_{it-1}$), and the state-contingent variables are replaced by observed variables by defining $c^T_{it} = c^T_i(s_t)$, $c^N_{it} = c^N_i(s_t)$, and $y_{it} = y^N_i(s_t) + y^T_i(s_t)$ for all s_t; and u_{it} is a well-behaved error term. Note that this formulation assumes that the income changes Δy_{it} are idiosyncratic, which is a typical assumption made in the existing studies on consumption risk-sharing. Then the consumption risk-sharing hypothesis is supported when $\beta_Z = 0$ holds. Note that in equation (2), α includes the *average* growth rate of tradables consumption within each risk-sharing network. Another important coefficient to be estimated is β_1, which involves the share of tradables in expenditures and the elasticity of substitution between tradables and non-tradables. By following Baxter and Jermann (1999) and Lewis (1996), we can approximate the elasticity of substitution between tradables and non-tradables by $(1 - \beta_1)(1 - x_T)/[\gamma(\beta_1 x_T + 1 - x_T)]$, where x_T is the share of tradables in expenditures and γ is the parameter of relative risk aversion.

Because total consumption expenditure is a composite of tradables and non-tradables, we can use the geometric weighted average of tradables and non-tradables to express total consumption, c; that is, $\ln c = w \ln c^T_{it} + (1 - w) \ln c^N_{it}$. Then, following Backus and Smith (1993), equation (2) can be rewritten as follows:

$$(3) \qquad \Delta \ln c_{it} = a + b_1 \Delta \ln c^N_{it} + b_Z \Delta \ln y_i + \varepsilon_{it},$$

where $a = w\alpha$, $b_1 = w\beta_1 + (1 - w)$, and $b_Z = w\beta_Z$. In equation (3), the full consumption risk-sharing hypothesis is represented by the condition $b_Z = 0$. Because the canonical test of consumption risk sharing excludes the term for non-tradables consumption, $\Delta \ln c^N_{it}$, such a test might involve omitted variable bias arising from self-production under non-separable utility.

However, income changes variables are not necessarily exogenous to a household, resulting in possible estimation biases arising from endogeneity, measurement error, and/or problems with private information. To mitigate such problems, when estimating equations (2) and (3), we use natural disaster shock information as instrumental variables for income changes as well as self-production changes. As an unexpected, exogenous event that cannot be affected by households, a natural disaster provides for an unusual and clean experimental situation under which one can test whether households are able to insure. Moreover, a disaster can cause large enough damage so that the noise-to-signal ratio in the disaster-related shock variable is significantly small and the data are less susceptible to attenuation bias arising from measurement error. Also, whereas the shock variables in existing studies are likely to be private information rather than public knowledge, damage caused by natural disasters is visible and easily verifiable. Hence, the assumption of perfect information is less problematic.

3. Data and Descriptive Statistics

In the present study, we use a combination of two data sets: (1) the Vietnam Household Living Standards Survey (VHLSS) 2006 data and (2) data from a resurveying of VHLSS 2006 respondents collected jointly by the Research Institute of Economy, Trade and Industry (RIETI) and the Center for Agricultural Policy in Vietnam (CAP; hereafter, the RIETI-CAP data).

The VHLSS is a biennial, nationally representative, rotating-panel household survey conducted by the General Statistics Office with technical assistance from United Nations Development Programme (UNDP) and the World Bank. This multipurpose household survey covers a variety of topics, such as household characteristics, expenditures, income, health, and education. Enumeration areas are chosen randomly from the 1999 Population Census enumeration areas, and households are selected randomly from each enumeration area. VHLSS 2006 covers approximately 46,000 households, of which approximately 9,000 include both the income and expenditure modules (the rest include only the income module) apart from other basic information.

The income module identifies the income that each household member received in the form of salary/wages or self-employment from a given industry, for example, agriculture, fishery, forestry, industry, construction, and trade and services, as well as from other sources, for example, remittance. The expenditures module provides very detailed information on bought or bartered items as well as the consumption of self-produced items and gifts. These data include both aggregate as well as itemized data.

The RIETI-CAP survey was designed to resurvey subsamples of VHLSS 2006 households from late February 2008 through early April 2008. We looked at past losses from avian influenza and flooding, which is one of the most common natural disasters in Vietnam. As a result, the following four provinces were chosen for the resurvey: (1) Ha Tay (hit only by avian influenza), (2) Nghe An (hit only by flooding), (3) Quang Nam (hit by both avian influenza and flooding), and (4) Lao Cai (hit by neither avian influenza nor flooding). The RIETI-CAP includes data from households both with and without the VHLSS 2006 expenditures module. The survey covers around 500 households for each province, for a total of 2,018 households. The survey includes a variety of data, such as changes in income and in expenditures, changes in asset holdings, insurance subscriptions, borrowing situations, past losses due to epidemics and natural disasters, willingness to pay for various hypothetical insurance schemes, and preferences regarding uncertainty and time. The income and the expenditures modules of the survey were designed to be compatible with VHLSS 2006, although the data are not as detailed as VHLSS data: Rather than asking about levels, the RIETI-CAP survey contains data regarding the rates of change in income (total and itemized) and/or expenditures/consumption (total and itemized).[5]

Table 1 reports descriptive statistics for the variables used in this paper. Note that the variables regarding natural disasters and epidemics are the numbers of disasters or epidemics experienced in the past five years (as of 2008). Among them, the variable “typhoons” includes hail as well as typhoons, and the variable “epidemics” includes both avian influenza and other epidemics. Household size is the number of household members. Figure 1 shows the distribution of the value of consumption of self-produced goods to the total value of consumption.

4. Empirical Results

Table 2 reports the estimation results for equation (2). It indicates that in the estimation of equation (2) by simple ordinary least squares (specification [1]), the coefficient of income becomes significant, and thus the consumption risk-sharing hypothesis is rejected. The qualitative results remain the same even if we use instrumental variable estimations for self-production and income change variables (specifications [2] and [3]), or even if we include province fixed effects (specification [4], [5], and [6]) on top of that. The first-stage regression results for income and self-production variables are shown in Tables 7 and 8, respectively.

The last two specifications [8] and [9] in Table 2, however, indicate otherwise. When the commune fixed effect is taken into account in the IV specifications, the income coefficient turns out to be statistically insignificant. In these cases, we cannot

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5 To mitigate potential bias from retrospective questions on change rates, we follow a procedure suggested by Nakata et al. (2010). All the qualitative results are maintained even if we handle retrospective bias.

reject the full consumption risk-sharing hypothesis, suggesting that risk-sharing networks function effectively at the commune level.

Table 3 reports the estimation results using total consumption expenditure as the dependent variable based on the canonical specification used by Townsend (1994) and those corresponding to equation (3), that is, results for the specification that reflect non-tradables. There are three important findings. First, coefficients of the income change variables are significant in all cases except for the model with the self-production variable and commune fixed effects in specifications [17] and [18]. Second, once we include both the self-production variable and commune fixed effects, income change coefficients are statistically insignificant (specifications [17] and [18]). These results imply that although risk-sharing networks may function effectively within each commune, the inter-community risk-sharing mechanism is weak. Third, with non-tradable goods, the coefficients of income become systematically smaller than those without non-tradables. This suggests that the omission of the self-production variable involves omitted variable bias. Indeed, the correlation coefficient between the log of non-tradable goods and the log of income is positive (0.3183) and statistically significant. As a consequence, the coefficient of the log of income would have an upward bias in the short specifications without non-tradables.

In sum, our estimation results indicate that the full consumption risk-sharing hypothesis holds if we consider a village-level risk-sharing network. Yet for larger networks (e.g., at the province level), our results do not support full risk sharing. Although we replicate the results found by Townsend (1994), the results change if we include self-production according to equation (3). These results suggest that the canonical consumption risk-sharing test *à la* Townsend (1994) should have involved omitted variable bias arising from self-production under non-separable utility.

Estimation of the Elasticity of Substitution

According to equation (8) of Lewis (1996), we are able to identify the elasticity of substitution between tradables and non-tradables by the formula $(1 - \beta_1)(1 - x_T)/[\gamma(\beta_1 x_T + 1 - x_T)]$. To this end, we need data on the relative risk aversion parameter, γ, to identify the elasticity of substitution. In order to elicit risk preference parameters, we followed Anderson et al. (2004) and carefully designed our structured questionnaire. More specifically, we assumed the constant relative risk aversion utility function and identified the ranges of the relative risk-aversion parameter γ by using the responses to the following questions:

"Imagine a fair coin flip. Choose the option that you prefer by circling (a) or (b) for each pair below.

- *4-1 (a) Whatever the outcome (heads or tails), you receive 30,000 VND; or (b) If the outcome is heads, you receive 60,000 VND, but you receive nothing if it is tails.*
- *4-2 (a) Whatever the outcome (heads or tails), you receive 30,000 VND; or (b) If the outcome is heads, you receive 75,000 VND, but you receive nothing if it is tails."*

The summary of the observed relative risk aversion parameter is shown in Table 4. For more than 60 percent of respondents, their degree of relative risk aversion exceeds 0.24. Tanaka et al. (2010) conducted artefactual field experiments among respondents to the 2002 Vietnam Living Standard Measurement Survey. Their results indicate relative risk aversion parameters of 0.37 for respondents in the south and 0.41 for those in the north. To account for possible measurement error, we use a range of risk aversion parameters, namely, 0.4, 1, 2, and 4, to compute the elasticity of substitution.[6]

The distribution of the elasticity of substitution is shown in Figure 2. As can be seen from this figure, the overall elasticity is very small. This implies that purchased consumption items and self-produced consumption items are imperfect substitutes, suggesting the importance of distinguishing between these two items.

5. Friction to Perfect Consumption Risk Sharing

In order to explore the reasons behind the acceptance of the full consumption risk-sharing hypothesis, we incorporate two sources of friction, that is, limited credit access and limited commitment.

Limited Credit Access

We first test the validity of consumption risk sharing framework among those who are credit constrained from formal and informal sources. In theory, we include an additional constraint, $c^T_{it} \leq y^T_{it}$, for those who are credit constrained to the optimization problem of (1). In this case, we should observe that $\beta_Z > 0$ for credit-constrained households in equation (2).

To elicit the credit constraint information, following Scott (2000), we carefully

[6] For the coefficient of non-tradable consumption β_1, we use the result from specification [18] in Table 3.

designed the questionnaire so that the credit constraints could be identified directly from the data set. The procedure was as follows: Household heads were asked about their experiences borrowing from formal and informal sources, such as government agencies, agricultural development banks, commercial banks, credit unions, cooperatives, nongovernmental organizations, microfinanciers, pawnshops, ROSCA (*Choi Ho* or *Hui*), landlords, employers, relatives, and friends during the past 12 months. We defined two indicator variables of credit constraints that were weak and strict versions of indicators: The strong indicator was for those who faced binding constraints in both 2006 and 2007, and the weak indicator was for those who faced binding constraints in either 2006 or 2007. We first asked whether a household had attempted to obtain a loan. Then, for those who had tried to borrow money, we asked whether the household was able to borrow the total amount requested. If the answer was yes, we identified the household as being unconstrained. In contrast, we identified those households whose loan requests had been rejected or accepted on a partial-amount basis as being credit constrained. We asked respondents who had not attempted to borrow about the reason for not availing themselves of a bank loan. Those who selected "no need for credit" from among the answer choices were considered as being unconstrained with regard to formal and/or informal credit sources. This is the weak version of the credit constraint indicator.

The estimation results of equations (2) and (3) reported in Table 5 are based only on the sample of credit-constrained respondents. These results indicate that the full consumption risk-sharing hypothesis is now rejected among those who are credit constrained in two out of four "full" specifications, namely, the specifications in which we controlled for self-production and used natural disaster shock as instrumental variables for self-production and income changes.[7] This result suggests that credit market imperfections are a likely source of incomplete consumption risk sharing.

Limited Commitment

Because a third party does not enforce risk-sharing arrangements, there is an issue of limited commitment in consumption risk sharing (Kocherlakota, 1996; Ligon, Thomas, and Worrall, 2002; Ligon, 2008; Kinnan, 2010; Laczo, 2010). Limited commitment arises when some households receive unusually high incomes. This is simply because such households are required to make large transfers to others under full insurance arrangements and thus have an incentive to leave the insurance network. Under such cases, we need to formulate a risk sharing model with a limited commitment constraint, as is shown in Kocherlakota (1996), Ligon, Thomas, and Worrall (2002), Kinnan (2010), and Laczo (2010). Strictly speaking, we need to solve problem (1) under an additional constraint for commitment:

$$\sum_{t=\tau}^{\infty}\left(\frac{1}{1+\delta}\right)^{t}\sum_{s^t}\pi(s_t)u_j\left[c_j^T(s_t),\, y_j^N(s_t)\right]\geq\sum_{t=\tau}^{\infty}\left(\frac{1}{1+\delta}\right)^{t}\sum_{s^t}\pi(s_t)u_j\left[y_j^T(s_t),\, y_j^N(s_t)\right].$$

This constraint shows that the expected utility of a household from staying within the insurance network is no less than the expected utility under autarky. A testable

[7] Although the full consumption risk-sharing hypothesis is rejected among those who are credit constrained (Table 5), the hypothesis is not rejected when we estimate an interaction variable of a dummy variable of credit constraints and income. The latter result is not presented in the paper, but is available upon request.

implication of such a model is that idiosyncratic income and individual consumption should co-move because households with higher income shocks should be given larger consumption to stay within the insurance network.

Unlike Kinnan (2010) and Laczo (2010), our strategy is to use direct information on commitment constraints. From the commune data from VHLSS 2006, we can identify the communities that have experienced internal conflicts. We presume that such communities are facing commitment problems. More specifically, the survey includes the following question: “What are the current most thorny social issues in the commune?” If the answer to this question includes “burglary” or “conflict/disunity,” the commitment constraint dummy takes a value of 1. Then our empirical approach is to include the dummy variable for binding commitment constraints in risk sharing equations (2) or (3) to estimate the coefficient of an interaction variable of the dummy and income change variables. If the estimated coefficient is positive and statistically significant, then the result is consistent with consumption risk sharing under the binding commitment constraint. Table 6 shows the estimation results. The interaction terms of the limited commitment dummy and income change variables are positive in three out of four specifications, but these coefficients are statistically insignificant.[8] This result suggests that limited commitment is not necessarily serious in communities in Vietnam. This is consistent with a finding by Kinnan (2010).

[8] For a robustness check of the results, we estimate the model by using two different subsamples; (a) households from communes where the either burglary or conflict/disunity is the most serious issue in the commune, and (b) households from communes where either burglary and/or conflict/disunity is among the most three serious issues in the commune. In either case, the consumption risk sharing model is not rejected. These results are available upon request.

6. Concluding Remarks

In this paper, we use unique household data from Vietnam collected by resurveying respondents to the VHLSS 2006. These data allow us to statistically test the necessary conditions for consumption risk sharing in detail. The main contributions of our study are threefold. First, we augment the canonical approach to testing the risk-sharing hypothesis by explicitly considering self-production. By doing so, we aim to examine the importance of heterogeneities in consumption. Second, we use data on natural disasters such as avian influenza, droughts, and floods to investigate the effectiveness of market and non-market mechanisms against natural disasters. Third, we examine the effects of two potential sources of friction—limited credit access and limited commitment—on full consumption risk sharing within a community.

With an explicit treatment of self-production and a use of natural disaster shocks as instrumental variables for income changes, we find that the full consumption risk-sharing hypothesis cannot be rejected. Our results suggest that the results of previous studies that have tended to reject the full risk-sharing hypothesis involve omitted variable bias arising from the lack of an explicit consideration of self-production. We also find that credit access is an important source of risk sharing but that limited commitment is not necessarily serious in Vietnamese villages.

Our results may suggest that the lack of efficient informal insurance mechanisms is compensated for by self-production. Because industrialization may lessen this role of self-production as a self-insurance device, it is important to mitigate risks associated with self-production by designing formal *ex ante* risk-management mechanisms against natural disasters. For example, the development of markets for index-type insurance associated with agricultural production would be an important topic in future research.

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Appendix: Justification of the Social Planner Problem

Consider an economy with J households (indexed by j = 1, 2, …, J) and I goods (indexed by i = 1, 2, …, I). Suppose that each household j has its own production function f^H_{ji} for each good i (we call this a *home production function*). The home production function maps the labor input z^H_{ji} to its output, which is denoted by y^H_{ji}. However, another set of technologies uses the labor input of multiple households, which we call the *industrialized production*. Let z^M_{ji} denote household j's labor input for the production of good i. Then the industrialized production function for good i is $f^M_i(z^M_{1i}, z^M_{2i}, \ldots, z^M_{Ji})$ with

$$y^M_i = f^M_i(z^M_{1i}, z^M_{2i}, \ldots, z^M_{Ji}),$$

where y^M_i is the output of the industrialized production of good i.

Let c_{ji} denote household j's consumption of good i. The feasibility constraint of the economy will therefore be

(A-1) $$\sum_{j=1}^{J} c_{ji} \leq \sum_{j=1}^{J} y^H_{ji} + y^M_i, \quad \forall i.$$

Now, let c^H_{ji} denote household j's consumption of its own home production of good i. Note that by definition, $c^H_{ji} \leq y^H_{ji} = f^H_{ji}\left(z^H_{ji}\right)$, household j will be self-sufficient concerning good i if $c_{ji} = c^H_{ji}$. Moreover, household j does not trade (i.e., buy or sell) good i if $c_{ji} = c^H_{ji} = y^H_{ji}$. This leads to the following definitions:

(a) *Good i is <u>non-tradable for household j</u> if* $c_{ji} = c^H_{ji} = y^H_{ji}$ *holds.*
(b) *Good i is <u>non-tradable</u> if* $c_{ji} = c^H_{ji} = y^H_{ji}$ *holds for all j.*
(c) *Good i is <u>fully tradable</u> if it is non-tradable for no j.*
(d) *Good i is <u>partially tradable</u> if it is non-tradable for some j.*

Note that if good i is non-tradable, then y^M_i = 0 holds as long as no free disposal is allowed. Now, if all goods are non-tradable (i.e., if there is autarky), it is easy to see that condition (A-1) must be replaced with $c_{ji} = y^H_{ji}$ for all i, j. Clearly, the condition $c_{ji} = y^H_{ji}$ for all i, j implies condition (A-1) but not vice versa; that is, the autarky condition is more restrictive than condition (A-1).

Let $\mathbf{J} = \{1, 2, ..., J\}$ and $\mathbf{J}_i = \{j \in \mathbf{J} : c_{ji} = y_{ji}^H\}$, that is, the set of households for whom good i is non-tradable. Also, let $\mathbf{I} = \{1, 2, ..., I\}$ and $\mathbf{I}^N = \{i \in \mathbf{I} : \mathbf{J}_i \text{ is non-empty}\}$, that is, the set of goods that are partially tradable or non-tradable. Now, if there is some good i that is partially tradable, that is, $\mathbf{I}^N$ is non-empty, then condition (A-1) must be replaced with

(A-2) $$\sum_{j=1}^{J} c_{ji} \le \sum_{j=1}^{J} y_{ji}^H + y_i^M, \quad \forall i \in \mathbf{I} \setminus \mathbf{I}^N,$$

(A-3) $$\sum_{j \in \mathbf{J} \setminus \mathbf{J}_i} c_{ji} \le \sum_{j \in \mathbf{J} \setminus \mathbf{J}_i} y_{ji}^H + y_i^M, \quad \forall i \in \mathbf{I}^N,$$

(A-4) $$c_{ji} = y_{ji}^H, \quad \forall j \in \mathbf{J}_i, \forall i \in \mathbf{I}^N.$$

Note that condition (A-2) is for fully tradable goods, condition (A-3) is for partially tradable goods, and condition (A-4) is for partially tradable or non-tradable goods. Observe that conditions (A-2), (A-3), and (A-4) imply condition (A-1) but not vice versa. In other words, the three conditions are more restrictive than condition (A-1).

The social optimum of the economy with the presence of some partially tradable goods will be characterized as the following social planner's problem (given the optimal production):

$$\max_{\langle c_{ij} \rangle_{i,j}} \sum_{j=1}^{J} \lambda_j U_j \left(c_{j1}, c_{j2}, \ldots, c_{jI}; L_j \right) \quad \text{subject to (A-2), (A-3) and (A-4),}$$

where λ_j is some positive weight (Pareto-Negishi weight) and L_j is household j's leisure, that is, time available minus labor. Now, as long as $\mathbf{I}^N$ is non-empty, condition (A-4) is present, and good $i \in \mathbf{I}^N$ is non-tradable for at least some households. It follows that a generic form of the social planner's problem in Lewis (1996) applies here, unless all goods are perfect substitutes. Note that this holds true even if the same good is non-tradable for some households but not for other households, that is, only the existence of a partially tradable good is enough, if not non-tradable (for all households).

Figure 1

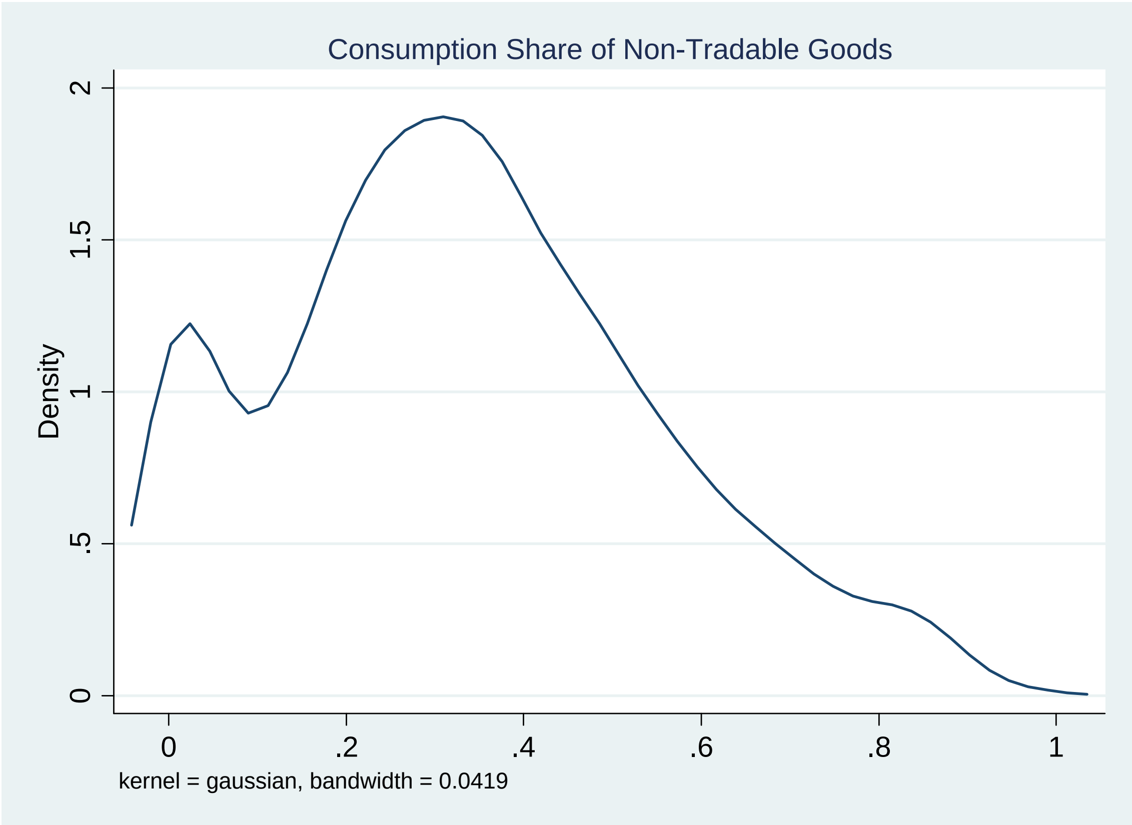
Consumption Share of Non-Tradable Goods
Density
0
.5
1
1.5
2
0
.2
.4
.6
.8
1
kernel = gaussian, bandwidth = 0.0419

Figure 2

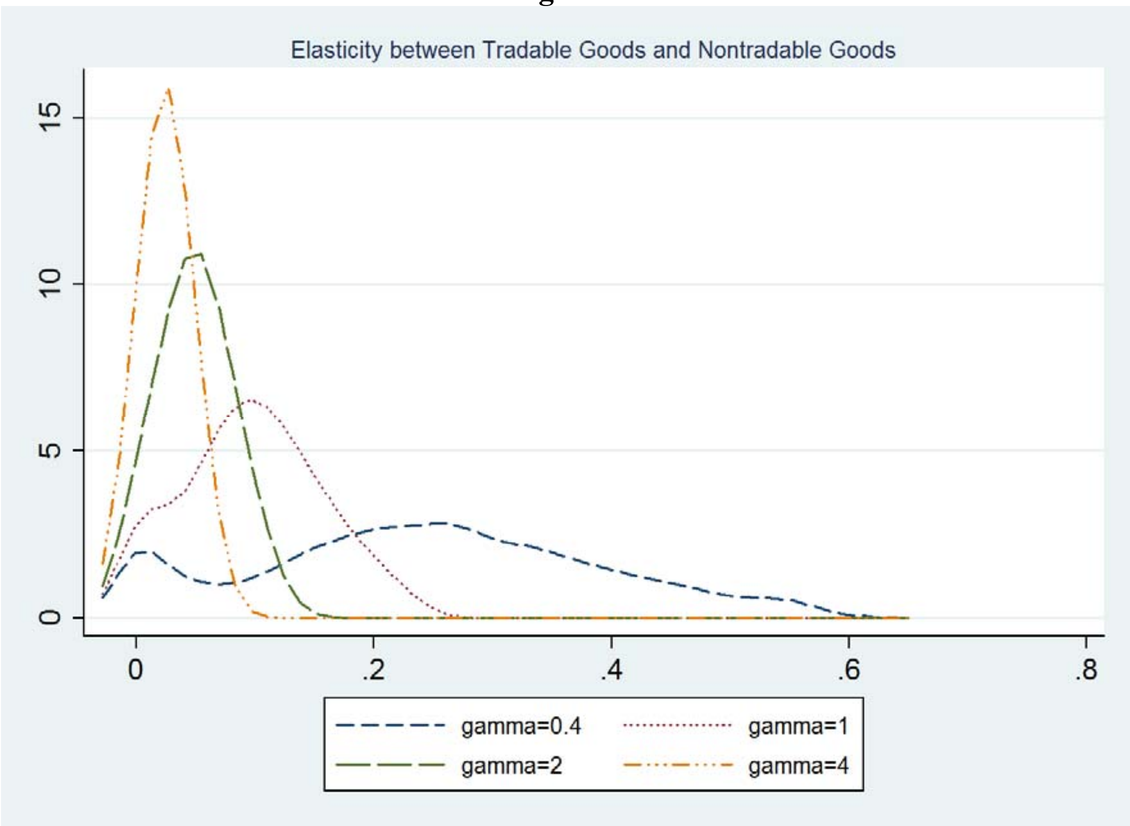
Elasticity between Tradable Goods and Nontradable Goods
0
5
10
15
0
.2
.4
.6
.8
gamma=0.4
gamma=1
gamma=2
gamma=4

Table 1

Descriptive Statistics

Variable	Code	Obs.	Mean	Std. Dev
First difference of log tradable consumption	tradable	2003	0.112	0.109
First difference of log non-tradable consumption	non-tradable	1850	0.080	0.122
First difference of log total income	income1	2006	0.101	0.098
First difference of log total consumption	total	1847	0.104	0.100
Total number of disasters in 2007	disaster1	4010	0.290	0.545
Total number of disasters in 2006	disaster2	4010	0.174	0.412
Number of landslides in 2007	geo_2007	4010	0.002	0.050
Number of landslides in 2006	geo_2006	4010	0.001	0.035
Number of typhoons in 2007	meteo_2007	4010	0.051	0.220
Number of typhoons in 2006	meteo_2006	4010	0.078	0.270
Number of floods in 2007	hydro_2007	4010	0.098	0.301
Number of floods in 2006	hydro_2006	4010	0.025	0.156
Number of droughts in 2007	climato_2007	4010	0.017	0.131
Number of droughts in 2006	climato_2006	4010	0.006	0.080
Number of epidemics in 2007	bio_2007	4010	0.084	0.287
Number of epidemics in 2006	bio_2006	4010	0.058	0.238
Number of other disasters in 2007	other_2007	4010	0.037	0.192
Number of other disasters in 2006	other_2006	4010	0.005	0.074
Value of real estate in 2006 (in thousand VND)	land	2014	2722.815	21656.110
Value of capital assets in 2006 (in thousand VND)	asset3	2014	22251.570	47480.960
Household size in 2006	num	2014	4.252	1.716
Income level in 2006 (in thousand VND)	income06	2014	29232.530	73354.400
Credit constraint dummy (1 if both 2006 and 2007 credit constraints are binding)	constraint	2014	0.295	
Credit constraint dummy (1 if either 2006 or 2007 credit constraint is binding)	constraint2	2014	0.408	
Limited commitment dummy (1 if a limited commitment constraint is binding)	limited	4171	0.122	

Table 2

Test of Consumption Risk Sharing

[Based on Equation (2), Dependent Variable: $\Delta \ln c^T$]

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Method	OLS	IV(5)	IV(6)	OLS	IV(5)	IV(6)	OLS	IV(5)	IV(6)
Province fixed effect	No	No	No	Yes	Yes	Yes	No	No	No
Commune fixed effect	No	No	No	No	No	No	Yes	Yes	Yes
Specification of the first-stage regression in Appendix Tables 1 and 2		(A)	(B)		(A)	(B)		(A)	(B)
$\Delta \log c^N$+	0.330***	0.507***	0.509***	0.310***	0.469	0.677***	0.321***	0.684	0.791***
	[0.067]	[0.106]	[0.088]	[0.063]	[0.307]	[0.157]	[0.064]	[0.444]	[0.174]
$\Delta \log y$ +	0.303***	0.581***	0.565***	0.240***	0.945**	0.451**	0.191***	0.511	0.253
	[0.040]	[0.165]	[0.130]	[0.049]	[0.425]	[0.208]	[0.033]	[0.569]	[0.212]
Constant	0.053***	0.01	0.01	0.061***			0.065***		
	[0.005]	[0.013]	[0.010]	[0.004]			[0.006]		
Number of observations	1839	1813	1813	1839	1813	1813	1839	1812	1812
R-squared	0.28	0.14	0.15	0.22	0.28	0.04	0.22	0.13	0.13
Hansen J statistic		5.54	19.55		0.94	22.62		2.08	9.5
Chi-sq(3) P-val		0.14	0.11		0.82	0.05		0.56	0.73
Number of provinces				34	34	34			
Number of communes							134	132	132

Robust standard errors are in brackets. + represents an endogenous variable. Instrumental variables for self-generated production and income changes are as follows: For IV(5), log of the total number of natural disasters in 2006 and 2007, log of capital assets, log of real estate, and log of household size. For IV(6), log of the number of landslides, typhoons, floods, droughts, epidemics, and other disasters in 2006 and 2007; log of capital assets; log of real estate; and log of household size. ** significant at 5%; *** significant at 1%

Table 3

Test of Consumption Risk Sharing

[Based on Equation (3), Dependent Variable: Δ ln *c*]

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Method	OLS	OLS	IV(5)	IV(6)	IV(5)	IV(6)	OLS	OLS	IV(5)	IV(6)	IV(5)	IV(6)	OLS	OLS	IV(5)	IV(6)	IV(5)	IV(6)
Province FE	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Commune FE	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Specification of the first-stage regression in Appendix Tables 1 and 2			(A)	(B)	(A)	(B)			(A)	(B)	(A)	(B)			(A)	(B)	(A)	(B)
$\Delta\log c^N$+		0.471***			0.638***	0.658***		0.456***			0.503*	0.752***		0.463***			0.777**	0.899***
		[0.073]			[0.078]	[0.064]		[0.077]			[0.271]	[0.125]		[0.073]			[0.337]	[0.119]
$\Delta\log y$ +	0.447***	0.258***	0.973***	1.033***	0.469***	0.430***	0.352***	0.211***	1.482***	1.067***	0.952**	0.409**	0.301***	0.164***	1.330***	0.959***	0.436	0.171
	[0.037]	[0.037]	[0.150]	[0.109]	[0.137]	[0.100]	[0.051]	[0.043]	[0.287]	[0.178]	[0.378]	[0.164]	[0.040]	[0.024]	[0.266]	[0.181]	[0.440]	[0.145]
Constant	0.059***	0.040***	0.007	0.006	0.006	0.007	0.069***	0.046***					0.074***	0.050***				
	[0.004]	[0.005]	[0.015]	[0.011]	[0.011]	[0.008]	[0.005]	[0.003]					[0.004]	[0.006]				
Number of observations	1839	1839	1813	1813	1813	1813	1839	1839	1813	1813	1813	1813	1839	1839	1812	1812	1812	1812
R-squared	0.19	0.49	0.07	0.13	0.37	0.38	0.12	0.43	0.12	0.14	0.12	0.21	0.09	0.45	0.1	0.15	0.14	0.11
Hansen J statistic			23.02	29.84	5.97	19.56			2.3	18.85	1.02	20.63			2.32	18.58	1.12	8.67
Chi-sq(3) P-val			0	0.01	0.11	0.11			0.68	0.17	0.8	0.08			0.68	0.18	0.77	0.8
Number of provinces							34	34	34	34	34	34						
Number of communes													134	134	132	132	132	132

Robust standard errors are in brackets. + represents an endogenous variable. Instrumental variables for self-generated production and income changes are as follows: For IV(5), log of the total number of natural disasters in 2006 and 2007, log of capital assets, log of real estate, and log of household size. For IV(6), log of the number of landslides, typhoons, floods, droughts, epidemics, and other disasters in 2006 and 2007; log of capital assets; log of real estate; and log of household size. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4

Ranges of the Relative Risk Aversion Parameter

Range of γ	Frequency	Percentage
0 < γ	505	25.91
0 < γ < 0.24	265	13.6
0.24 > γ	1179	60.49
Total	1949	100

Table 5

Test of Consumption Risk Sharing for the Credit-Constrained Group

Specification	(1)	(2)	(3)	(4)
Dependent Variable	Δ ln c^T	Δ ln c^T	Δ ln c	Δ ln c
Method	IV(5)	IV(6)	IV(5)	IV(6)
Province fixed effect	No	No	No	No
Commune fixed effect	Yes	Yes	Yes	Yes
Specification of the first-stage regression in Appendix Tables 1 and 2	(A)	(B)	(A)	(B)
Δlog c^N+	0.806	0.511***	0.809**	0.641***
	[0.500]	[0.114]	[0.388]	[0.096]
Δlog y +	0.162	0.413*	0.242	0.374**
	[0.696]	[0.229]	[0.508]	[0.165]
Constant				
Number of observations	527	527	527	527
R-squared	0.02	0.25	0.43	0.53
Hansen J statistic	3.23	12.87	3.36	17.37
Chi-sq(3) P-val	0.36	0.46	0.34	0.18
Number of communes	100	100	100	100

Robust standard errors are in brackets. + represents an endogenous variable. Instrumental variables for self-generated production and income changes are as follows: For IV(5), log of the total number of natural disasters in 2006 and 2007, log of capital assets, log of real estate, and log of household size. For IV(6), log of the number of landslides, typhoons, floods, droughts, epidemics, and other disasters in 2006 and 2007; log of capital assets; log of real estate; and log of household size. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 6
Test of Consumption Risk Sharing under Limited Commitment Constraints

Specification	(1)	(2)	(3)	(4)
Dependent Variable	Δ ln c^T	Δ ln c^T	Δ ln c	Δ ln c
Method	IV(5)	IV(6)	IV(5)	IV(6)
Province fixed effect	No	No	No	No
Commune fixed effect	Yes	Yes	Yes	Yes
Specification of the first-stage regression in Appendix Tables 1 and 2	(A)	(B)	(A)	(B)
$\Delta\log c^N$+	0.677	0.780***	0.789**	0.923***
	[0.506]	[0.210]	[0.366]	[0.137]
$\Delta\log y$ +	0.361	0.248	0.346	0.15
	[0.652]	[0.222]	[0.481]	[0.148]
$\Delta\log y$ *limited commitment dummy+	2.345	0.076	1.246	-0.265
	[1.941]	[1.213]	[1.352]	[0.889]
Number of observations	1812	1812	1812	1812
R-squared	0.49	0.11	0.01	0.07
Hansen J statistic	0.2	8.97	0.05	7.9
Chi-sq(3) P-val	0.9	0.71	0.97	0.79
Number of provinces				
Number of communes	132	132	132	132

Robust standard errors in brackets. + represents an endogenous variable. Instrumental variables for self-generated production and income changes are as follows: For IV(5), log of the total number of natural disasters in 2006 and 2007, log of capital assets, log of real estate, and log of household size. For IV(6), log of the number of landslides, typhoons, floods, droughts, epidemics, and other disasters in 2006 and 2007; log of capital assets; log of real estate; and log of household size. ** significant at 5%; *** significant at 1%

Appendix Table 1

First-Stage Regressions for Log of Income Growth

[Dependent Variable: Δlog *y*]

Specification	(A)	(B)	(A)	(B)	(A)	(B)
	IV(5)	IV(6)	IV(5)	IV(6)	IV(5)	IV(6)
Province fixed effect	No	No	Yes	Yes	No	No
Commune fixed effect	No	No	No	No	Yes	Yes
lnland2	0.033***	0.027***	0.008	0.006	0.014	0.011
	[0.009]	[0.008]	[0.008]	[0.008]	[0.009]	[0.009]
lnnum2	0.028***	0.026***	0.010*	0.010*	0.009	0.01
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
lnasset3	0.004**	0.005**	0.007***	0.007***	0.007***	0.007***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
disaster1	-0.025***		0.001		-0.006	
	[0.007]		[0.008]		[0.008]	
lngeo_2007		0.106***		0.084***		0.041
		[0.031]		[0.029]		[0.037]
lnmetero_2007		-0.027		-0.001		-0.028
		[0.018]		[0.020]		[0.026]
lnhydro_2007		-0.023*		0.025		0.034*
		[0.014]		[0.017]		[0.020]
lnclimato_2007		-0.026**		0.004		0.011
		[0.013]		[0.013]		[0.017]
lnbio_2007		0.008		-0.002		-0.006
		[0.011]		[0.010]		[0.011]
lnother_2007		-0.064***		-0.030*		-0.044**
		[0.011]		[0.017]		[0.017]
lndisaster2	-0.019**		-0.006		-0.004	
	[0.008]		[0.008]		[0.009]	
lngeo_2006		0.046		0.035		0.013
		[0.046]		[0.045]		[0.031]
lnmeteo_2006		-0.033**		0.015		0.011
		[0.015]		[0.021]		[0.025]
lnhydro_2006		-0.060**		-0.028		-0.033
		[0.027]		[0.023]		[0.029]
lnclimato_2006		-0.081***		-0.025		-0.015
		[0.019]		[0.020]		[0.019]
lnbio_2006		0.011		-0.01		-0.003
		[0.011]		[0.012]		[0.013]
lnother_2006		-0.02		-0.007		-0.02
		[0.052]		[0.052]		[0.051]
Constant	0.013	0.014				
	[0.017]	[0.016]				
Number of observations	1813	1813	1812	1812	1812	1812
R-squared	0.05	0.01	0.02	0.02	0.13	0.13
F test: coeff. of IV = 0	8.65	5.86	5.73	2.72	2.08	9.5
Prob > F	0	0	0	0	0.56	0.73
Number of provinces		34				
Number of communes			132	132	132	132

Robust standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix Table 2

First-Stage Regressions for Log of Non-Tradable Consumption Growth

[Dependent Variable: $\Delta \log c^N$]

Specification	(A)	(B)	(A)	(B)	(A)	(B)
	IV(5)	IV(6)	IV(5)	IV(6)	IV(5)	IV(6)
Province fixed effect	No	No	Yes	Yes	No	No
Commune fixed effect	No	No	No	No	Yes	Yes
lnland2	0.033***	0.027***	0.008	0.006	0.014	0.011
	[0.009]	[0.008]	[0.008]	[0.008]	[0.009]	[0.009]
lnnum2	0.028***	0.026***	0.010*	0.010*	0.009	0.01
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
lnasset3	0.004**	0.005**	0.007***	0.007***	0.007***	0.007***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
disaster1	-0.025***		0.001		-0.006	
	[0.007]		[0.008]		[0.008]	
lngeo_2007		0.106***		0.084***		0.041
		[0.031]		[0.029]		[0.037]
lnmetero_2007		-0.027		-0.001		-0.028
		[0.018]		[0.020]		[0.026]
lnhydro_2007		-0.023*		0.025		0.034*
		[0.014]		[0.017]		[0.020]
lnclimato_2007		-0.026**		0.004		0.011
		[0.013]		[0.013]		[0.017]
lnbio_2007		0.008		-0.002		-0.006
		[0.011]		[0.010]		[0.011]
lnother_2007		-0.064***		-0.030*		-0.044**
		[0.011]		[0.017]		[0.017]
lndisaster2	-0.019**		-0.006		-0.004	
	[0.008]		[0.008]		[0.009]	
lngeo_2006		0.046		0.035		0.013
		[0.046]		[0.045]		[0.031]
lnmeteo_2006		-0.033**		0.015		0.011
		[0.015]		[0.021]		[0.025]
lnhydro_2006		-0.060**		-0.028		-0.033
		[0.027]		[0.023]		[0.029]
lnclimato_2006		-0.081***		-0.025		-0.015
		[0.019]		[0.020]		[0.019]
lnbio_2006		0.011		-0.01		-0.003
		[0.011]		[0.012]		[0.013]
lnother_2006		-0.02		-0.007		-0.02
		[0.052]		[0.052]		[0.051]
Constant	0.013	0.014				
	[0.017]	[0.016]				
Number of observations	1813	1813	1813	1813	1812	1812
R-squared	0.04	0.07	0.02	0.02	0.02	0.03
F test: coeff. of IV = 0	13.13	10.63	6.05	3.6	4.93	2.49
Prob > F	0	0	0	0	0	0
Number of idcode			34	34		
Number of comid					132	132

Robust standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%