The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

The Determinants of Rice Storage: Evidence from Rice Farmers in Bangladesh

Jeffrey D. Michler
Dept. of Agricultural Economics
Purdue University
West Lafayette, IN
jmichler@purdue.edu

Joseph V. Balagtas
Dept. of Agricultural Economics
Purdue University
West Lafayette, IN
balagtas@purdue.edu

Selected Paper prepared for the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

Copyright 2013 by Jeffrey D. Michler and Joseph V. Balagtas. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

1 Introduction

Rice is the primary food staple in Bangladesh and a major incentive for rice cultivation is to satisfy household demand for rice. Unlike in developed countries, where the sole purpose of grain storage is assumed to be for price arbitrage, in rural villages, where access to markets is limited, households may hold sizable rice stocks to ensure that they can satisfy their consumption needs (Park, 2006). Absent well developed insurance and credit markets and due to high market transaction costs, the rural household attempts to self-insure against both yield and price risk by storing rice. However, rice storage is costly, beacuse it may tie up wealth in an unproductive form (Giles and Yoo, 2007). The need to store rice reduces a household's ability to cultivate cash crops, engage in more profitable off-farm employment, and invest in education, among other things. The degree to which households store rice thus plays an important role in the future prospects for economic growth in rural communities. Policies aimed at increasing growth opportunities for rural households in Bangladesh must understand the motivation for rice storage if they hope to be effective.

We econometrically test several hypotheses that arise from an examination of the recent literature on grain storage by semi-subsistence households. We adopt a model of household storage decision making developed by Saha and Stroud (1994) which provides flexibility to account for more recent evidence. Augmenting the model with literature on precautionary savings, we are able to propose five testable hypotheses. These include the role of risk preferences in household decision making, whether households store grain for arbitrage only or for food security reasons also, and the effect income and credit constraints have on the level of grain storage. The results of these tests allow us to draw conclusions about the role of grain storage in developing countries and make pro-growth policy recommendations.

2 Literature Review

While the existence of high levels of staple grain storage by semi-subsistence households is well documented, there exists distinct, though not mutually exclusive, views on the reasons why households choose to store grain. Park (2006), among others (Renkow, 1990; Saha and Stroud, 1994), argue that staple grain storage is a unique form of precautionary savings, since the grain is also the primary consumption good for the household. Households receive a convenience yield from stored grain such that they may choose positive storage levels even when the future expected price is lower than the spot price plus the cost of storage. This food security motive for storage means households that store grain when successful price arbitrage is unlikely are storing to insure their consumption of calories and not their consumption of all other goods (Deininger et al., 2007). Thus, relaxing income or credit constraints may not change storage behavior.

Other economists argue that staple grain storage is like any other type of precautionary savings and thus requires no special treatment in models of household decision making (Giles and Yoo, 2007; Lee and Sawada, 2010). Households store grain not because they can consume it but because the grain is a liquid asset that provides a safe, but modest, return on investment (Stephens and Barrett, 2011). In this view, the only motivation for storage is the price arbitrage one discussed in Working (1949) where the convenience yield from storage comes from its liquidity. While this means that households might store grain when successful price arbitrage is unlikely, such a situation would only persist if households had no other options (Giles and Yoo, 2007). In fact, a recent study suggests that even when price arbitrage is likely, constraints may be so severe as to not even allow households to effectively use storage as a form of precautionary savings (Stephens and Barrett, 2011). Thus, relaxing income or credit constraints, by providing better methods to self-insure, will change storage behavior.

These views on the role of grain storage are not mutually exclusive but are rather different positions along a spectrum. Towards one end are those that see the dominant motivation for grain storage among semi-subsistence households as little different from the motivation for grain storage in developed countries. Towards the other end are those that see semi-subsistence households undertaking grain storage for reasons unique to the developing world. While not mutually exclusive, these views do yield testable predictions on what will influence household storage decisions. Better access to credit, for example, increases storage for arbitrage reasons and decreases storage for food security reasons. The net effect on storage is an empirical question, which is where we position our work

3 A Model of Household Rice Storage

In examining households' storage decisions we follow the model developed by Saha and Stroud (1994). This model is preferred to the others discussed in Section 2 for several reasons. It improves on Renkow (1990) by modeling by generalizing the framework to allow for risk aversion. Additionally, the Saha and Stroud model makes what we fell is an intuitive distinction between the precautionary savings of staple food and other types of precautionary savings. This allows the model to make distinctions Giles and Yoo (2007) and Lee and Sawada (2010) are unable to do. Finally, the model estimated by Stephens and Barrett (2011) does not directly address the storage question. Rather, they estimate consumption and market participation equations and make inferences on storage from their results. However, the Saha and Stroud model is not perfect. Its income measure is coarse and it assumes the existence of perfect factor markets, including credit.

3.1 The Saha & Stroud Model

Households are price takers in both the input and output markets. Each household can be represented by an time-wise additively sperable and time-invariant utility function. The household maximizes the following utility function over T periods.

$$U(\cdot) = \sum_{t=0}^{T} \psi^t U(c_t, y_t, l_t) \tag{1}$$

c, y, l represent consumption all other goods, and leisure, respectively. Subscripts represent the time period and ψ is the discount rate. Household production as well as consumption consist of a single good, in this case rice. Rice production can be consumed or sold.

The household's income at time t is given by the equation

$$we_t = p_t\big[Q_t(\mathbf{L}_t) + S_t - S_{t+1}\big] + A_t(\mathbf{L}_t) + rb_t - C(S_{t+1}) \tag{2}$$

where rice price is p, storage is S, the net cost of storage is C, and b is other forms of savings besides physical rice storage. $\mathbf{L}$ is a vector of labor inputs, both hired and family. $Q(\cdot)$ is farm output which is solely a factor of labor. Finally, $A(\cdot)$ is the household's net labor income - earnings from off farm labor minus on farm labor expenses. Both $A(\cdot)$ and $Q(\cdot)$ are not time-invariant, hense the subscript t on each function. This allows for seasonal changes in labor practices.

The remaining equations in the model are an expenditure identity and a savings identity. Household expenditures equal

$$M_t = p_t c_t + y_t \tag{3}$$

where the price of y has been normalized to unity. The savings identity requires

$$b_{t+1} - b_t = we_t - M_t \tag{4}$$

Substituting equation (2) and (3) into (4) yields

$$y_t = p_t m_t + \Delta b_t + A_t(\mathbf{L}_t) - C(S_{t+1}) \tag{5}$$

where $m_t = Q_t(\mathbf{L}_t) + S_t - S_{t+1}$.

Unlike the two-period Saha (1994) model used by Stephens and Barrett (2011) where second period price always exceed first period price, in this model there is output price risk. Saha and Stroud (1994) use $\tilde{p}_{t+1}$ for the unknown future price. They assume that $\tilde{p}$ is generated by a stationary Markov process, meaning that $\tilde{p}_{t+1}$ is conditional only on p_t.

The household's optimization problem, then, is

$$\max_{\mathbf{z}_t} H = U\big[c_t, p_t m_t + \Delta b_t + A_t(\mathbf{L}_t) - C(S_{t+1}), l_t(\mathbf{L}_t)\big] + \psi \mathrm{E}_t\big[V^{t+1}\tilde{p}_{t+1}, \tilde{y}_{t+1})\big] \tag{6}$$

where $\mathbf{z}_t \equiv [c_t, \mathbf{L}_t, b_{t+1}, S_{t+1}]$ is the vector of decision variables to be maximized. The term E_t is the expectation operator at time t and it is taken on the value function, $V^{t+1} = \sum_{i=t+1}^{T} \psi^t U[c_i^*, y_i^*, l_i(\mathbf{L}_i^*)]$. The superscript $*$ denotes the optimal choices for each variable.

The first order conditions for equation (6) which maximize $\mathbf{z}_t$ are the following

$$\begin{aligned}
H_{c_t} &\equiv U_{c_t} - p_t U_{y_t} \equiv 0 & (7)\\
H_{\mathbf{L}_t} &\equiv \big\{p_t Q_{tL_t}(\mathbf{L}_t) + A_{tL_t}(\mathbf{L}_t)\big\} U_{y_t} + l_{tL_t}(\mathbf{L}_t) \equiv \mathbf{0} & (8)\\
H_{b_{t+1}} &\equiv -U_{y_t} + (1+r)\psi \mathrm{E}_t\big[V_y^{t+1}\big] \equiv 0 & (9)\\
H_{S_{t+1}} &\equiv -\big\{p_t + C'(S_{t+1})\big\} U_{y_t} + \psi \mathrm{E}_t\big[V^{t+1}(\tilde{p}_{t+1}\big] \equiv 0 & (10)
\end{aligned}$$

It is from these equations that Saha and Stroud (1994) were able to derive equation (**??**), their sufficient condition for positive levels of storage (See Appendix **??** for mathematical details).

While the Saha and Stroud model has several nice features, it is also missing some features desirable in a model of semi-subsistence household storage. These include a more nuanced measure of income and consideration for incomplete credit markets. At this point we have not added these missing features to the model or come up with new solutions. To some degree this is not necessary, since of all the studies discussed only Renkow (1990) estimates a structural model. Instead, we can use the Saha and Stroud (1994) model, along with the insights from Giles and Yoo (2007), Lee and Sawada (2010), and Stephens and Barrett (2011) to construct testable hypotheses regarding determinants of storage.

3.2 Testable Hypotheses

The literature reviewed in Section 2 yields competing hypotheses regarding the dominant reason households choose to store grain. The Saha and Stroud (1994) model and its econometric analogue will allow us to address the relative importance of the two motivations. Specifically, we am interested in verifying the following five hypotheses for rural rice growing households in Bangladesh.

- **H1**: Households are **risk neutral** rather than risk averse.
- **H2**: Households store rice to engage in inter-temporal **price arbitrage**.
- **H3**: Households do not store rice to ensure **food security**.
- **H4**: Households store more rice when the **income constraint** is binding.
- **H5**: Households store more rice when the **credit constraint** is binding.

Hypothesis 1 allows us to test whether the Renkow (1990) model or the generalized model of Saha and Stroud (1994) is more appropriate for understanding semi-subsistent household behavior. Hypothesis 2 allows us to test the long held belief that households store grain to take advantage of higher expected future prices. Hypothesis 3 allows us to test if models that account for a food security convenience yield are more appropriate than models that consider storage equivalent to any other form of precautionary savings. Hypothesis 2 and 3 together allows us to test the relative importance of the two potential motivations for storage put forward by Renkow along with Saha and Stroud. Hypothesis 4 allows us to test Giles and Yoo's (2007) findings that an increase in off-farm income reduces a household's reliance on storage. Hypothesis 5 allows us to test whether the Lee and Sawada (2010) story or the Stephens and Barrett (2011) story about credit's affect on storage is true. Validation of Hypothesis 5 supports the Lee and Sawada story that households store grain to smooth consumption. Rejection of Hypothesis 5 supports the Stephens and Barrett story that greater access to credit allows households to better arbitrage the inter-temporal price relation.

4 Survey Data

To conduct our econometric estimation we usehousehold level data from rice growing villages in Bangladesh collected as part of the Village Dynamics Study of South Asia (VDSA). This data set is a combination of high and low frequency household data from India and Bangladesh. The low frequency data consists of household level survey data from 62 villages for the years 1988, 2000, and 2004. This data provides historical context for the high frequency data which is being collected in 12 Bangladeshi villages on a monthly basis. The first two years of data (covering the crop growing years 2009-10 and 2010-2011) was released 7 November 2012.

To conduct our estimation of our model equations (11) and (12) the VDSA data set provides detailed household level data at monthly intervals. The great benefit of the VDSA data set is the detailed information on consumption (c) as well as hours of labor hired (hfl)

and hours of family farm and domestic labor (*ffl*). Regarding independent variables, we have already discussed the method for obtaining expected prices and price variance. we will also need data on wages for hired (wh) and family labor (wf), which we can obtain directly from the VDSA data or derive in a manner similar to Saha and Stroud (1994). A measure of full income (we) is not difficult to derive from the data but such a measure does create problems of endogeneity. This is not an uncommon problem nor is it particularly difficult to resolve. Saha and Stroud (1994) use total annual net revenue minus total cost of farm production and loan repayment. They then divided the full income instrument into quarters (twelfths in our case). Giles and Yoo (2007) follow a similar method.

Regarding the dummy variable for access to credit (Dcr), the VDSA data contains detailed information on credit market transactions. we will follow Stephens and Barrett's (2011) approach by combining agricultural credit (in cash or kind) with non-agricultural credit into a binary variable. This variable will equal 1 if any type of credit was used and 0 otherwise. The remaining variables (ov, Dp, Dh) can be straightforwardly constructed from the existing data.

5 Empirical Strategy

My empirical analysis is based on a household optimization model developed by Saha and Stroud (1994). Define optimal household choice as

$$\mathbf{z}_t^*(\phi) \equiv \left\{ c_t^*(\phi), S_{t+1}^*(\phi), L_t^*(\phi) \right\} \tag{11}$$

ϕ is a vector of parameters, c denotes food consumption, S denotes storage levels, and L denotes a vector of labor inputs that include hired farm labor (*hfl*) and family farm labor (*ffl*). Note that optimal savings (b_{t+1}^*) is subsumed in each period's income. These optimal decision variables are functions of current rice price (p_t), the first two moments of the distribution of next period's rice price, the wages for hired (wh) and family labor (wf), the share of the household working outside of the village (ov), total income (we), a dummy variable for credit use (Dcr), and dummy variables for the harvest (Dh) and planting (Dp) seasons.

$$\phi_t = \Big\{p_t, \mathrm{E}\,[\tilde{p}_{t+1}], \mathrm{Var}\,[\tilde{p}_{t+1}], wh_{\mathrm{t}}, wf_{\mathrm{t}}, ov_{\mathrm{t}}, we_{\mathrm{t}}, Dcr_{\mathrm{t}}, Dp_{\mathrm{t}}, Dh_{\mathrm{t}}\Big\} \tag{12}$$

This setup allows us to estimate a system of seemingly unrelated regression equations of the form

$$\mathbf{y} = \mathbf{X}\beta + \mathbf{u} \tag{13}$$

where $\mathbf{y}$ is a vector of the dependent variables (c, S, hfl, ffl), $\mathbf{X}$ is a matrix of regressors corresponding to those in Equation (12), β is a vector of parameters to be estimated, and $\mathbf{u}$ is a vector of error terms.

Estimation requires the generation of data regarding price expectations. Nerlove et al. (1995) suggests generating forecasts using an autoregressive integrated moving average (ARIMA) process. In their work Saha and Stroud (1994) found an AR(1) process to be most appropriate. This allows us to estimate $\mathrm{E}\,[\tilde{p}_{t+1}] = \theta p_t$ and $\mathrm{Var}\,[\tilde{p}_{t+1}] = \theta[p_t - \theta p_{t-1}]^2$. we will jointly estimate the θ parameter with the other parameters in Equation (13).

Empirically testing the hypotheses stated in Section 3.2 requires writing out the estimation equations. The equations are the same for all four dependent variables in $\mathbf{y}$. we use the storage determinant equation as illustration.

$$\begin{aligned} S_t = \alpha_1 + \alpha_2 p_t + \alpha_3 \theta p_t + \alpha_4 \theta [p_t - \theta p_{t-1}]^2 + \alpha_5 wh_t \\ + \alpha_6 wf_t + \alpha_7 ov_t + \alpha_8 we_t + \alpha_9 Dcr_t + \alpha_{10} Dp_t + \alpha_{11} Dh_t + u_t \end{aligned} \tag{14}$$

Using an ARIMA process to generate data on expectations means that we will not be able to identify the coefficients α_2, α_3, and α_4 so we rewrite the previous equation as

$$
\begin{aligned}
S_t = \beta_0 + \beta_1 p_t + \beta_2 p_t^2 + \beta_3 p_{t-1}^2 + \beta_4 p_t p_{t-1} + \beta_5 wh_t \\
+\beta_6 wf_t + \beta_7 ov_t + \beta_8 we_t + \beta_9 Dcr_t + \beta_{10} Dp_t + \beta_{11} Dh_t + u_t
\end{aligned}
\tag{15}
$$

In order to test the importance of price variance (the food security motive) in the household storage decision we must recover the α_4 parameter. However, the parameter is over identified, entering into β_2, β_3, and β_4. We will need to deal with the nonlinear parameter restrictions, namely,

$$\alpha_4 = \frac{\beta_2 \beta_4}{2\beta_3} = \frac{2\beta_2^2}{\beta_4}$$

Having recovered the α_4 parameter, we can then construct tests for each of the five hypotheses.

- **H1: risk neutral** The null hypothesis that a household is risk neutral is

$$\mathbf{H1}_0 : \beta_2 = \beta_3 = \beta_4 = 0 \tag{16}$$

  Rejection of the null supports Saha and Stroud's (1994) case for modeling semi-subsistence households as risk averse. Acceptance of the null supports Renkow's (1990) model of risk neutral households.

- **H2: price arbitrage** The null hypothesis that households engage in inter-temporal price arbitrage is

$$\mathbf{H2}_0 : \beta_1 > 0 \tag{17}$$

Rejection of the null supports the case made by Renkow (1990) and Saha and Stroud (1994) that price arbitrage is not a significant motivation for grain storage. However, rejection does not necessarily allow us to reject Giles and Yoo (2007), Lee and Sawada (2010), and Stephens and Barrett (2011) who argue that price arbitrage is the dominant motive. As Stephens and Barrett (2011) showed, households may be unable to engage in arbitrage due to credit constraints. Thus, rejection of **H2** could mean that households are willing but unable to engage in price arbitrage.

- **H3: food security** The null hypothesis that households do not store food to help ensure food security is

$$\mathbf{H3}_0 : \alpha_4 = 0 \tag{18}$$

Rejection of the null supports the case made by Renkow (1990) and Saha and Stroud (1994) that households earn significant food security convenience yields. Acceptance of the null supports the case made by Giles and Yoo (2007), Lee and Sawada (2010), and Stephens and Barrett (2011) that storage is like any other type of precautionary savings.

- **H4: income constraint** The null hypothesis that increases in remittance income reduce storage levels is

$$\mathbf{H4}_0 : \beta_7 < 0 \tag{19}$$

Rejection of the null (combined with rejection of H3) supports Renkow (1990) and Saha and Stroud's (1994) contention that, since grain is stored for food security, changes in income will not significantly reduce storage. Acceptance of the null (combined with acceptance of H3) supports Giles and Yoo's (2007) contention that grain storage is a form of unproductive savings that households engage in only due to income constraints. Rejection (acceptance) of the null combined with acceptance (rejection) of H3 lends partial support to both groups.

- **H5: credit constraint** The null hypothesis that access to credit reduce storage levels is

$$\mathbf{H5}_0 : \beta_9 < 0 \tag{20}$$

Rejection of the null (combined with acceptance of H2) supports Stephens and Barrett's (2011) argument that increasing access to credit will allow households to better engage in price arbitrage. Acceptance of the null supports Lee and Sawada's (2010) argument that increasing access to credit will reduce a household's reliance on storage. Since Lee and Sawada (2010) view grain storage as a form of unproductive savings that households engage in only due to credit constraints, support for their position does not require anything from H2.

6 Conclusion

Data analysis is on going but preliminary results support the notion that households engage in rice storage for both precautionary savings and for price arbitrage reasons. We estimate that for the median household 30% of store rice is stored for food security reasons. The remaining 70% is stored in the hopes of engaging in price arbitrage. However, among households in the lower income quartile 50% of rice is stored for food security reasons. An even more dramatic increase in rice storage for precautionary reasons can be seen among severally risk averse households. Households with coefficients of relative risk aversion in the upper quartile store 70% of rice for food security reasons, leaving only 30% of stored rice for arbitrage.

It should be noted that our data analysis is preliminary as we continue to instrument the econometric model to account for endogeneity. However, our preliminary results tell a clear economic story. Poor and severally risk averse households store rice primarily for food security reasons and thus must forgo potential arbitrage opportunities. Households that are wealthier or less risk averse are able to use methods other than rice storage to insure consumption and thus avail themselves of potentially lucrative arbitrage opportunities.

Bibliography

Adnan, S. (1999). Agrarian structure and agricultural growth trends in bangladesh: The political economy of technological change and policy interventions. In B. Rogaly, B. Harriss-White, and S. Bose (Eds.), *Sonar Bangla? Agricultural Growth and Agrarian Change in West Bengal and Bangladesh*. New Delhi: Sage Publications.

Baker, G., R. Gibbons, and K. J. Murphy (2002). Relational contracts and the theory of the firm. *Quarterly Journal of Economics 117*, 39–84.

Banerji, A., J. Meenakshi, and G. Khanna (2012). Social contracts, markets and efficiency: Groundwater irrigation in north india. *Journal of Development Economics 98*(2), 228–237.

Deininger, K., S. Jin, and X. Yu (2007). Risk coping and starvation in rural china. *Applied Economics 39*, 1341–1352.

Dixit, A. K. (2004). *Lawlessness and Economics: Alternative Modes of Governance*. Princeton University Press.

FAO (2011). Towards a food secure bangladesh: Country programming framework 2010-2015. Technical report, The Ministry of Agriculture, Government of Peoples Republic of Bangladesh and Food and Agriculture Organization of the United Nations.

Giles, J. and K. Yoo (2007). Precautionary behavior, migrant networks, and household consumption decisions: An empirical analysis using household panel data from rural china. *Review of Economics and Statistics 89*(3), 534–551.

Hayami, Y. and K. Otsuka (1993). *The Economics of Contract Choice: An Agrarian Perspective*. Clarendon Press.

Hossain, M. (2009). Shallow tubewells, *Boro* rice, and their impact on food security in bangladesh. In D. Spielman and R. Pandya-Lorch (Eds.), *Millions Feed: Proven Successes in Agricultural Development*.

Ihli, H. J., S. Maart, and O. Musshoff (2012). Investment and disinvestment in irrigation technology – an experimental analysis of farmers' decision behavior. In *Agricultural & Applied Economics Association's 2012 AAEA Annual Meeting*.

Kajisa, K. and T. Sakurai (2003). Determinants of groundwater price under bilateral bargaining with multiple modes of contracts: A case from madhya pradesh, india. *Japanese Journal of Rural Economics 5*, 1–11.

Kajisa, K. and T. Sakurai (2005). Efficiency and equity in groundwater markets: The case of madhya pradesh, india. *Environment and Development Economics 10*(6), 801–819.

Kaldor, N. (1939). Speculation and economic stability. *Review of Economic Studies 7*(1), 1–27.

Kaplan, R. D. (2010). *Monsoon: The Indian Ocean and the Future of American Power*. New York: Random House.

Lee, J.-J. and Y. Sawada (2010). Precautionary saving under liquidity constraints: Evidence from rural pakistan. *Journal of Development Economics 91*, 77–86.

Mukherji, A. (2004). Groundwater markets in ganga-meghna-brahmaputra basin: Theory and evidence. *Economic and Political Weekly 3*(31), 3514–3520.

Nerlove, M., D. Grether, and J. L. Carvalho (1995). *Analysis of Economic Time Series, Revised Edition: A Synthesis*. New York: Academic Press.

Palmer-Jones, R. (2002). Irrigation service markets in bangladesh: Private provision of local public goods and community regulation. In *Symposium on Managing Common Resources: What is the Solution?*, Lund University, Sweden.

Palmer-Jones, R. (2010). Whatever happened to the water sellers? In *festschrift for Geof Wood,*, University of Bath.

Park, A. (2006). Risk and household grain management in developing countries. *Economic Journal 116*(514), 1088–1115.

Rahman, M. S. (2014). *Determinants of Water Price, Contract Mode, and the Production Inefficiency in Groundwater Irrigation in Bangladesh*. Ph. D. thesis, Bangladesh Agricultural University.

Rahman, M. W., M. R. Ahmed, and R. H. Sarwer (2011). An investigation of groundwater irrigation and command area management issues in bangladesh. *Journal of Knowledge Globalization 4*(1), 93–114.

Rahman, M. W. and L. Parvin (2009). Impact of irrigation on food security in bangladesh for the past three decades. *Journal of Environmental Protect 1*(3), 216–225.

Ravallion, M. (1987). *Markets and Famines*. Oxford: Clarendon Press.

Renkow, M. (1990). Household inventories and marketed surplus in semisubsistence agriculture. *American Journal of Agricultural Economics 70*(3), 664–675.

Saha, A. (1994). A two-season agricultural household model of output and price uncertainty. *Journal of Development Economics 45*, 245–269.

Saha, A. and J. Stroud (1994). A household model of on-farm storage under price risk. *American Journal of Agricultural Economics 76*(3), 522–534.

Schoengold, K. and D. Zilberman (2007). The economics of water, irrigation, and development. In R. Evenson and P. Pingali (Eds.), *Handbook of Agricultural Economics, Vol. 3*, pp. 2939–2984.

Shah, T. (1985). Transforming groundwater markets into powerful instrument of small farmer development. ODI Irrigation Management Network Paper, No. 11d.

Shah, T. (1988). Groundwater grids in the villages of gujarat: Evolution, structure, working and impacts. Institute of Rual Management, Anand.

Shah, T. (1991). Water markets and irrigation development in india. *Indian Journal of Agricultural Economics 46*(3).

Shah, T. (1993). *Groundwater Markets and Irrigation Development: Political Economy and Practical Policy*. Oxford University Press.

Shah, T., D. Zilberman, and U. Chakravorty (1993). Water rights doctrines and technology adoption. In K. Hoff, A. Braverman, and J. E. Stiglitz (Eds.), *The Economics of Rural Organization: Theory, Practice, and Policy*. New York: Oxford University Press.

Stephens, E. C. and C. B. Barrett (2011). Incomplete credit markets and commodity marketing behaviour. *Journal of Agricultural Economics 62*(1), 1–24.

Stiglitz, J. E. (1975). Incentive, risk sharing, and information: Notes toward a theory of hierarchy. *Bell Journal of Economics 6*(2), 552–579.

Wood, G. D. and R. Palmer-Jones (1991). *The Water Sellers: A Cooperative Venture by the Rural Poor*. Kumarian Press.

Working, H. (1949). The theory of price of storage. *American Economic Review 39*, 1254–1262.