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A Note on the Theoretical Framework for Seasonal Consumption Patterns in Developing Countries

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Abstract

This note discusses how seasonal price changes of a staple food affect farmers′ seasonal consumption in developing countries, where storage of the staple food can be used to smooth consumption. Crucially, sharp increases in the price of the staple food just before harvest can be viewed as a high return to savings, and this has important implications for interpreting consumption, savings, and borrowing behavior of poor rural households in developing countries. Especially in this situation, reduced relative consumption of produced staple goods in the hunger season compared with that in other seasons due to its high price in the hunger season should not be interpreted only as income and substitution effects. Rather, it could reflect inability to reallocate resources across seasons.

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1 Introduction

Seasonal hunger is an acute problem in many developing countries, especially in rain-fed agricultural areas. Many farmers store their harvests for own consumption until the next harvest, but sometimes their stocks run out before that harvest. Such farmers must buy food in the last month or two before the next harvest, when food prices are usually high. These months just before harvest are often called the hunger season, when malnutrition is common and most child deaths occur (Devereux et al., 2012). Thus, the impact of seasonal prices on consumption patterns is an important policy concern. This note makes two contributions to the theory of consumption smoothing in developing countries. First, it shows that higher prices in the hunger season may shift consumption to that season for households that save physical amounts of staple goods, unless they exhaust their stocks in that season. Second, it demonstrates, contrary to some authors' claims (e.g. Stephens and Barrett, 2011), that a binding borrowing constraint does not necessarily imply that households cannot smooth consumption across seasons.

2 Theoretical Framework

2.1 Conventional Model

Paxson (1993) initiated modern research on consumption smoothing in developing countries, and many subsequent papers adopt her model (e.g. Dercon and Krishnan, 2000, Chaudhuri and Paxson, 2002, and Khandker, 2012). Paxson assumed that there are two seasons, and considered the following farmer utility maximization problem:[1]

$$\max_{c_1,x_1,c_2,x_2,B} u(c_1, x_1 \mid \theta_1) + \beta u(c_2, x_2 \mid \theta_2) \tag{1}$$

$$\text{subject to} \quad p_1 c_1 + x_1 = y_1 + B \tag{2}$$

$$p_2 c_2 + x_2 + (1 + r)B = y_2 \tag{3}$$

$$B \leq \bar{B} \tag{4}$$

where c_j is a staple good consumed in season j with price p_j, x_j is a non-produced good consumed in season j with a time-invariant price normalized to one, y_j is income in season j, including the value of the staple good produced, B is money borrowed in season 1, with upper limit $\bar{B}$, β is a per season discount rate, r is the per season interest rate, and θ_j represents season-specific tastes. Season 1 occurs at the time of harvest, when the amount of harvest is determined, and consumption, sales, and saving decisions are made. Season 2 is the hunger season, when there is no agricultural production. The farmer's demand for the staple good in that season (season 2) is satisfied with his or her savings ($-B$) and/or off-farm income (y_2).

[1] Income uncertainty with a credit constraint leads to precautionary savings for prudent farmers. I ignore this, because it is not the central issue here. I simplify Paxson's infinite-period model to a two-period model for expositional convenience.

When (4) is not binding, the first order conditions for this problem yield the following:

$$\frac{u'(c_1 \mid \theta_1)}{u'(c_2 \mid \theta_2)} = \beta(1+r)\frac{p_1}{p_2} \tag{5}$$

$$\frac{u'(x_1 \mid \theta_1)}{u'(x_2 \mid \theta_2)} = \beta(1+r) \tag{6}$$

For clearer results, assume additive separability between the staple good and the non-produced good. This assumption allows one to ignore the indirect effect of seasonal price changes through the inter-temporal marginal rate of substitution of one good on that of the other. In this case, high prices of the staple good decrease the marginal rate of substitution of the produced staple good in season 2 for the same good in season 1, while the marginal rate of substitution of the non-produced consumption good in season 2 for that good in season 1 is unaffected by seasonal price changes of the staple good. That is, a higher price of the staple good in season 2 would shift the farmer's consumption of that good from season 2 to season 1.

When (4) binds ($B = \bar{B}$), the marginal utility of the staple good in season 1 is higher than its marginal utility in season 2, indicating the farmer's inability to smooth consumption across seasons. In this model, the farmer can borrow or save money, but cannot borrow or save quantities of the staple good. Thus, it implicitly assumes that either the staple good cannot be stored over time, or that the return to saving money equals or exceeds the return to saving stocks of the staple good. This assumption could be misleading in situations where farmers can store the staple good to smooth consumption (e.g. Kazianga and Udry, 2006, Stephens and Barrett, 2011, Basu and Wong, 2015).

2.2 Two-period Model with Storage of the Produced Staple Good

Next, modify the model to allow storage of the staple over seasons, and assume that saving physical quantities of the staple good is more profitable than saving money. This alters the predictions of the conventional model.[2] The following farmer's utility maximization problem becomes:

$$\max_{c_1,x_1,c_2,x_2,B,S} u(c_1, x_1 \mid \theta_1) + \beta u(c_2, x_2 \mid \theta_2) \tag{7}$$

$$\text{subject to} \quad p_1c_1 + x_1 + p_1S = y_1 + B \tag{8}$$

$$p_2c_2 + x_2 + (1+r)B = p_2(1-\nu)S + y_2 \tag{9}$$

$$B \leq \bar{B} \tag{10}$$

$$S \geq 0 \tag{11}$$

[2]This is similar to the Basu and Wong (2015) model, except that farmers can borrow limited amounts of money while saving the staple good. This yields a different interpretation of binding borrowing constraints from the conventional model, and allows a different interpretation of results in previous studies (e.g. Dercon and Krishnan, 2000) that higher prices reduce relative consumption in the hunger season.

where S is the amount of the staple good stored in season 1 for consumption or sale in season 2, ν is its physical depreciation rate during storage, and other notation is the same as above. Equation (11) imposes the assumption that, although farmers can save physical quantities of the staple good, they cannot borrow physical quantities of it in season 1.[3] Assume also that $p_2 > p_1$ and that p_2 is sufficiently high to satisfy:

$$\frac{p_2}{p_1}(1-\nu) > 1+r \tag{12}$$

This implies that saving money is never optimal, because saving by storing the staple good is more profitable. Under this condition, the farmer borrows money until $\bar{B}$ is reached, i.e. until (10) binds (assuming that storage capacity does not bind), so that he or she can purchase the staple good in season 1 (when the price is lower) for consumption or sale in season 2 (when the price is higher).[4] This binding monetary borrowing constraint should not be interpreted as a complete inability to smooth consumption across seasons, because farmers can reallocate consumption from season 1 to season 2 by storing the staple good. Instead, a higher $\bar{B}$ should be interpreted as a greater share of life-cycle income received in season 1.[5]

When (11) does not bind, the first order conditions yield:

- $$\frac{u'(c_1 \mid \theta_1)}{u'(c_2 \mid \theta_2)} = \beta(1-\nu) \tag{13}$$
- $$\frac{u'(x_1 \mid \theta_1)}{u'(x_2 \mid \theta_2)} = \frac{p_2}{p_1}\beta(1-\nu) \tag{14}$$

Assuming additive separability between the staple good and the non-produced good, higher prices in season 2 do *not* affect seasonal consumption patterns of the staple good. Intuitively, this is because a higher p_2 affects farmers in two ways: through the increased cost of the staple good in season 2, and through the higher return in season 2 from storing that good.

Price hikes in season 2 do not affect seasonal consumption patterns of the staple good

[3]In general, equation (11) can be replaced with $S \geq \underline{S}$, and the negative number of $\underline{S}$ allows one to consider the scenario where the farmer can borrow additional quantities of the staple good in season 1, and repays them in season 2 either in kind or with per season money interest rate of $\frac{p_2}{p_1}(1-\nu)-1$. This paper sets $\underline{S}=0$, because, although farmers in developing countries may be able to borrow the staple good from their neighbors, friends, or relatives, it is often the case that they can borrow only a small amount, and not at this interest rate. Note that borrowing of the staple good with per season interest rate of r is included in B.

[4]Stephens and Barrett (2011) allow for storage of physical grain. However, they implicitly assume that equation (12) holds with equality. Thus, the implications of their model are identical to those of the conventional model.

[5]Combine (8) and (9) by substituting out S. With $B=\bar{B}$, the inter-temporal budget constraint is $p_2(1-\nu)c_1 + \frac{p_2}{p_1}(1-\nu)x_1 + p_2c_2 + x_2 = \frac{p_2}{p_1}(1-\nu)y_1 + y_2 + \{\frac{p_2}{p_1}(1-\nu)-(1+r)\}\bar{B}$ where the right hand side represents life-cycle income. Short term credit programs which increase $\bar{B}$ will be beneficial (e.g. Basu and Wong 2015, and Fink, Jack, and Masiye, 2014.)

because the negative effect of a higher consumption price in season 2 is offset by higher returns to saving that good, which must be consumed in season 2. Further, equation (14) implies that an increase in the relative price of the staple good in season 2 *increases* the relative consumption of the *non-produced* good in season 2. This occurs because that good's price is time invariant while the returns to savings, due to the higher price of c_2, increases. These results are the *opposite* of those for Paxson's model, where an increase in p_2 reduced relative consumption of the staple in season 2, and did not affect the seasonal consumption patterns of non-produced good. Note that, despite the binding credit constraint, the marginal utility of the staple good in season 1 equals its marginal utility in season 2.

When equation (11) is binding ($S = 0$), the marginal utility in season 1 is higher than the marginal utility in season 2; once the farmer's stocks are exhausted, he or she would like to reallocate consumption from season 2 to season 1, but cannot do so: cash in hand in either season is used only for consumption in that season. In this case, a higher price for the staple in season 2 decreases its consumption in season 2 through both income and substitution effects, but does not affect its consumption in season 1. Thus, an increase in p_2 reduced relative consumption of the staple in season 2 only if the farmer wants to, but cannot, borrow physical amounts of the staple good in season 1.

3 Discussion

When produced staple goods are used to smooth consumption over time, seasonal price changes can affect seasonal consumption patterns not only through income and substitution effects, but also by changing the return to savings. In this situation, reduced relative consumption of produced staple goods in the hunger season compared with that in other seasons due to its high price in the hunger season should not be interpreted only as income and substitution effects. Rather, it could reflect inability to reallocate resources across seasons. Observing the lack of storage of the produced consumption good can identify such farmers. An implication for designing household surveys in developing countries is that they should collect data on physical grain storage in addition to collecting financial and livestock data.

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Appendix: Adding Uncertainty to the Model

Adding uncertainty to the two-period model with storage of the produced staple good would not change the implication of the model that sharp increases in the price of the staple food just before harvest can be viewed as a high return to savings.

To see this point, consider the situation where there is some uncertainty in the physical depreciation rate during storage (ν) due to exogenous shocks such as pest infestation. Uncertainty is defined in terms of a random variable $\rho \in ST = \{\rho_1, \rho_2, \cdots, \rho_N\}$ which can take a finite number N of values, and let $\pi(\rho)$ be the probability that state ρ occurs. The random variable ρ determines earnings in which $\nu(\rho)$ is the realized ν associated to state ρ in season 2. Without loss of generality, the realized depreciation rate can be ordered such that $\nu(\rho_1) > \nu(\rho_2) > \cdots > \nu(\rho_N)$. The farmer's utility maximization problem becomes:

$$\max_{c_1, x_1, \{c_2(\rho), x_2(\rho)\}_{\rho \in ST}, B, S} u(c_1, x_1 \mid \theta_1) + \beta \sum_{\rho \in ST} u(c_2(\rho), x_2(\rho) \mid \theta_2) \tag{15}$$

$$\text{subject to} \quad p_1 c_1 + x_1 + p_1 S = y_1 + B \tag{16}$$

$$p_2 c_2(\rho) + x_2(\rho) + (1+r)B = p_2(1-\nu)S + y_2 \qquad \text{with probability } \pi(\rho) \tag{17}$$

$$B \leq \bar{B} \tag{18}$$

$$S \geq 0 \tag{19}$$

where $c_2(\rho)$ and $x_2(\rho)$ are the consumption of the staple good and the non-produced good with a realization of state ρ in season 2 respectively, and the other notation is the same as above. Assume also that $p_2 > p_1$ and that p_2 is sufficiently high to satisfy:

$$\frac{p_2}{p_1}(1 - \nu(\rho_1)) > 1 + r \tag{20}$$

Under this condition, the farmer borrows money until $\bar{B}$ is reached. When equation (19) does not bind, the first order conditions yield:

- $u'(c_1 \mid \theta_1) = E[u'(c_2(\rho) \mid \theta_2)\beta(1 - \nu(\rho))]$ (21)
- $u'(x_1 \mid \theta_1) = E[u'(x_2(\rho) \mid \theta_2) \cdot \dfrac{p_2}{p_1}\beta(1 - \nu(\rho))]$ (22)

Assuming additive separability between the staple good and the non-produced good, higher prices in season 2 do *not* affect seasonal consumption patterns of the staple good, while an increase in the relative price of the staple good in season 2 *increases* the relative consumption of the *non-produced* good in season 2. This implication is the same as the implication discussed in the section 2.2.

Relaxing the assumption of equation (20) such that there exists $i \in [1, N]$ such that

$$\frac{p_2}{p_1}(1 - \nu(\rho_i)) < 1 + r \qquad \text{and} \qquad \frac{p_2}{p_1}(1 - \nu(\rho_{i+1})) > 1 + r \tag{23}$$

implies that a risk averse farmer may not borrow money up until the upper limit, because he or she does not want to allocate all the savings to the risky asset (the staple good). In this case, the return to savings for $(\bar{B} - B)$ is not $\frac{p_2}{p_1}(1 - \nu(\rho))$, but $(1 + r)$. The model implication is then in between that of the conventional model and of the two-period model with storage of produced staple good, depending on the degree of uncertainty.