Farm storage and asymmetric maize price shocks in Burkina Faso

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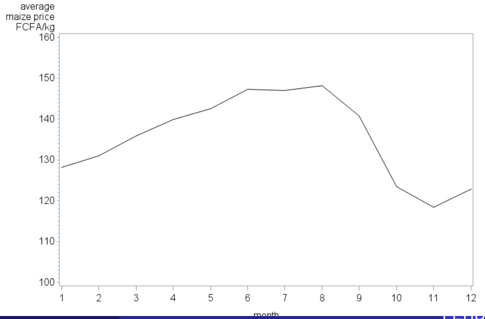
Motivation

What causes volatility?

Distinguish negative and positive price shocks

Farm storage

Figure: Average monthly maize prices in Burkina Faso, 33 markets, 10 years



Litterature

Storage and volatility: empirical evidence of a smoothing effect

The competitive storage model (Gustafson 1958, Deaton and Laroque 1992, Bobenrieth et al 2013)
Buy low sell high
Asymmetry

...differs from the rationale behind on farm storage (Saha and Stroud 1994, Park 2009)
Seasonal liquidity constraints
Sell low buy high!

Overview

- A conceptual model of farm storage
- Empirical strategy
- Empirical results

Farm storage model

Assumption 1: decrease in expected price

The farmer sells grain if he expects a price decrease. He is price taker, he sells out his stock

$$\text{if} \qquad p_t > \frac{E_t p_{t+1}}{1+\delta} \quad , \qquad x_t = y - \sum_{i=1}^{t-1} x_i$$

t month index
$E_t p_{t+1}$ expected price for next month
δ discount rate
y production surplus
x_i grain sales for month i.

Farm storage model

Assumption 2: increase in expected price

The farmer does not purchase grain if he expects a price increase. He is liquidity constrainted, he sells grain to purchase non grain good.

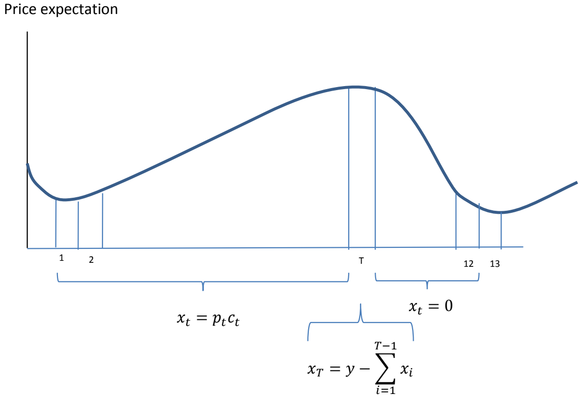
$$\text{if} \qquad p_t \leq \frac{E_t p_{t+1}}{1+\delta} \quad , \qquad x_t = p_t c_t$$

c_t non grain consumption at month i

Farm storage model

Assumption 3: the price expectation pattern

The farmer expects exactly one price peak per year.



Sales plan based on price expectations

Farm storage model

What if actual prices differ from expected price pattern?

Farm storage model

What if actual prices differ from expected price pattern?

Unexpected price drops before the expected price peak produces carryover (*Proposition 1*).

If some farmers ignore the existence of carry-over, carry-over generates unexpected price drop after harvest. (*Proposition 2*)

Farm storage model. Proposition 1

The case for carry-over, $\sum_{i=1}^{12} x_i < y$

1. The farmer misses the price peak (unexpected price drop at $t \leq \overline{T}$)

$$p_{t-1} < \frac{E_{t-1} p_t}{(1+\delta)}$$
$$p_{t-1} > \frac{p_t}{1+\delta}$$

2. and expects price increase after the price drop

$$\forall t \in [\overline{T}, 12], \frac{E_t p_{t+1}}{(1+\delta)} > P_t$$

Farm storage model. Proposition 2

Clearing market condition > equilibrium price

$x_{12+t}(\chi^1, y^2, p_{13}, ..., p_{12+t}, E_{12+t}p_{12+t+1}, ..., E_{12+t}p_{12+12}) = d_{12+t}(p_{12+t})$

->

$$p_{12+t}(\chi^1, y^2, p_{13}, ..., p_{12+t}, E_{12+t}p_{12+t+1}, ..., E_{12+t}p_{12+12})$$

$$\frac{\partial(p_{12+t} - E_{12+t-1}p_{12+t})}{\partial\chi^1} < 0$$

Carry-over generates unexpected price drop after harvest.
(*Proposition 2*)

Empirical strategy

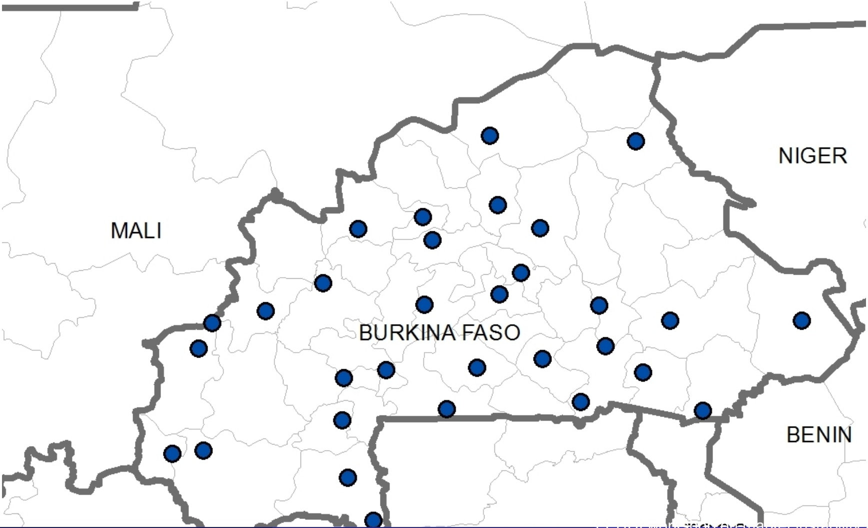
Step 1. Caracterizing unexpected price drops and spikes

- ARCH model
- SONAGESS data : 33 maize markets, 2002-2012

Step 2. Assessing the interaction between volatility and carry-over

- Panel estimation
- Agriculture Ministry data : 2175 households

Figure: Localization of the 33 studied markets



Empirical strategy

ARCH model structure

$$P_{mt} = \beta_0 + \beta_1 P_{mt-1} + \sum_{i=1}^{11} \beta_i D_i + \varepsilon_{mt} \qquad \varepsilon_{mt} \sim \mathcal{N}(0, h_{mt})$$

$$h_{mt} = \alpha_0 + \alpha_1 \varepsilon^2_{mt-1} + \nu_{mt} \qquad \nu_{mt} \sim \mathcal{N}(0, \sigma)$$

Positive volatility for market m between month τ_0 and month τ_1

$$h^{+}_{m\tau_0\tau_1} = \frac{1}{\tau_1 - \tau_0} \sum_{\substack{t=\tau_0 \\ \varepsilon_{mt}>0}}^{\tau_1} \hat{h}_{mt}$$

Negative volatility for market m between month τ_0 and month τ_1

$$h^{-}_{m\tau_0\tau_1} = \frac{1}{\tau_1 - \tau_0} \sum_{\substack{t=\tau_0 \\ \varepsilon_{mt}<0}}^{\tau_1} \hat{h}_{mt}$$

Empirical results

Figure: Maize real prices, 3 markets, 10 years

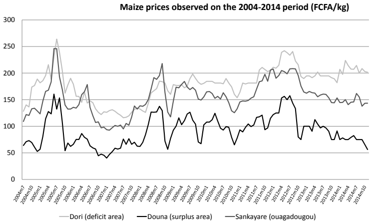
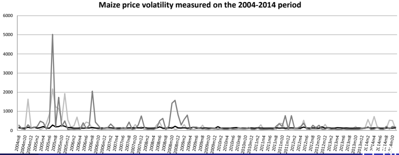
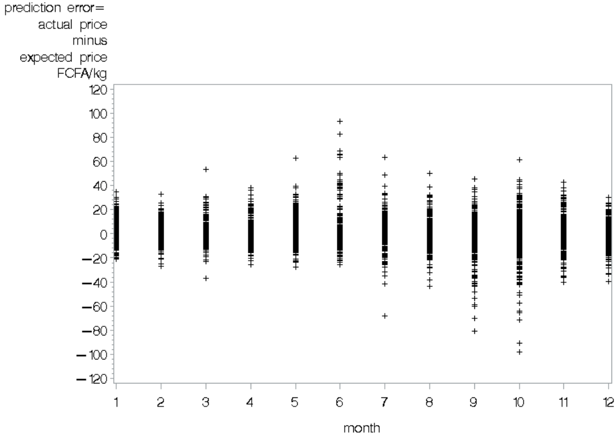


Figure: Maize price volatility, 3 markets, 10 years



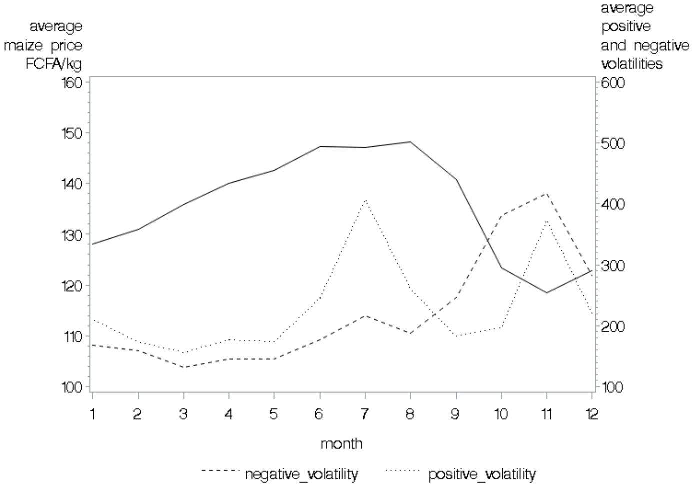
Empirical results

Figure: Distribution of maize price negative and positive error prediction within a year, Burkina Faso, 33 market places, 10 years



Empirical results

Average price and price negative and positive volatilities in Burkina Faso, 33 market places, 10 years



Empirical results

Table: Descriptive statistics, 33 markets, 2175 households

	Mean	Std. Dev.	Min	Max
Price (FCFA/kg)	123	33	46	206
Carry-over (maize kg)	21	577	0	6075
Harvest (maize kg)	112	1454	0	12960

Expected effect 1

$$\chi_{mj} = \gamma_0 + \gamma_1 \chi_{mj-1} + \gamma_2 h^{-}_{mj\tau_0\tau_1} + \gamma_3 y_{mj} + \theta_{mj} \quad (1)$$

Table: Effect of pre-harvest negative volatility on carry-over. GMM estimates

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Lagged stock	0,19	0,42	0,15	0,19	0,10	0,09	0,10	0,26
	***	***	***	ns	***	ns	ns	ns
Lagged negative volatility	0,28	0,38	0,57	1,13	0,33	0,96	1,33	-0,02
	**	ns	ns	**	ns	**	*	ns
Lagged harvest	0,13	0,06	0,22	0,06	0,10	0,19	0,23	0,06
	***	*	*	**	**	***	***	ns
Const	-36,68	-60,43	-214,66	113,88	123,39	-192,05	-279,28	10,85
	ns	ns	ns	*	ns	*	ns	ns
Obs	226	109	148	177	105	149	103	132
Period for lagged volatility	Nov-Oct	Jul	Jul-Aug	Jul-Sept	Aug	Aug-Sept	Sept	Oct

Empirical results

Expected effect 2

$$h^{-}_{mj\tau_0\tau_1} = \rho_0 + \rho_1 h^{-}_{mj-1\tau_0\tau_1} + \rho_2 \chi_{mj-1} + \rho_3 y_{mj-1} + \eta_{mj} \quad (2)$$

Table: Effect of carry-over on post-harvest negative volatility. GMM estimates

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Lagged volatility	0,13	-0,12	-0,14	-0,10	-0,09	0,00	0,07
	s	ns	**	**	*	ns	ns
Stock	0,02	0,09	0,12	0,13	0,11	0,11	0,06
	**	ns	***	*	**	**	*
Harvest	-0,03	0,01	-0,12	-0,07	-0,05	-0,04	-0,03
	*	ns	**	**	ns	ns	ns
Const	235,38	273,63	588,70	430,85	368,17	304,92	269,24
	***	ns	***	***	***	***	***
Obs	224	46	143	183	204	217	219
Period for volatility	Nov-Oct	Nov	Nov-Dec	Nov-Jan	Nov-Fev	Nov-Mars	Nov-Avr

Conclusion

Carry-over increases the occurrence of massive price drops after harvest.
> This effect stands for a 5 months period.
> This effect is robust to CV and EGARCH measures

What policy implications?

- ensure that carry-over will be nil at the end of the cropping season: improved access to market information systems
- encourage farmers to store their production after harvest by responding to their liquidity constraints : innovative systems as inventory credit where storage is used as a collateral

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Farm storage model

Maximisation of a CRRA utility function

$$EU = \max_{c_1,\tilde{c}_2^1,\dots\tilde{c}_{12(k-1)+12}^1,x_1,\tilde{x}_2^1,\dots\tilde{x}_{12(k-1)+T}^1}$$

$$\frac{c_1^{1-r}}{1-r} + \frac{1}{1+\delta}\frac{(\tilde{c}_2^1)^{1-r}}{1-r} + \dots + \frac{1}{(1+\delta)^{11}}\frac{(\tilde{c}_{12}^1)^{1-r}}{1-r} + \dots$$

$$\frac{1}{(1+\delta)^{12(k-1)}}\frac{(\tilde{c}_{12(k-1)+1}^1)^{1-r}}{1-r} + \dots + \frac{1}{(1+\delta)^{12(k-1)+11}}\frac{(\tilde{c}_{12(k-1)+12}^1)^{1-r}}{1-r}$$

One resource constraint per year

$$y - x_1 - \tilde{x}_2^1 - \dots - \tilde{x}_T^1 \geq 0$$

x_1 grain sale at month 1
$\tilde{x}_2^1$ planned sale at month 1 for month 2

model

One budget constraint per month

harvest month: $x_1 p_1 - c_1 \geq 0$

second month: $x_1 p_1 - c_1 + \tilde{x}_2^1 E_1 p_2 - \tilde{c}_2^1 \geq 0$

month $\overline{T}$: $x_1 p_1 - c_1 + \sum_{i=2}^{T} \tilde{x}_i^1 E_1 p_i - \sum_{i=2}^{12} \tilde{c}_i^1 \geq 0$

model

solution for initial sale plan
-> $c_1(y, p_1, E_1 p_2 ..., E_1 p_T, c_1, ...c_{t-1})$
-> $x_1(y, p_1, E_1 p_2 ..., E_1 p_T, c_1, ...c_{t-1})$

Similar maximisation every month
solution for revised sale plan
-> $c_t(y, c_1, ...c_{t-1}, p_1, ..., p_{t-1}, p_t, E_t p_{t+1} ..., E_t p_T)$
-> $x_t(y, c_1, ...c_{t-1}, p_1, ..., p_{t-1}, p_t, E_t p_{t+1} ..., E_t p_T)$