Agricultural Production and Technological Change

Advanced Producer Theory and Analysis: The Production of Annuals

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AREC 705: Week 6

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Haile et al. (2016) Overview

Haile, M.G., Kalkuhl, M. and von Braun, J. (2016), Worldwide Acreage and Yield Response to International Price Change and Volatility: A Dynamic Panel Data Analysis for Wheat, Rice, Corn, and Soybeans. *Amer. J of Ag. Econ., 98*: 172-190..

Contributions – what question(s) is the paper addressing? –

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Haile et al. (2016) Questions

General thoughts on the paper? Thoughts on literature review? –

How do the authors account for dynamic decision-making conceptually? Empirically? –

Are there any robustness checks you believe are missing? –

Why might collinearity between prices and price volatility introduce an identification concern? (P. 178) –

Why do they assume that deviations in yield from the trends are good proxies for yield expectations? Does this seem reasonable? (p. 178) –

Can you think of other input controls? (P. 178-179) –

Haile et al. (2016) Background

1. Expected Prices (Handout)
    - What forms of expected prices do Haile et al. use?
    - What form of expected prices do they find to be most predictive of production response?
    - How do these price choices overcome some of the common concerns related to the formation of price expectations?
2. Measures of output
    - What measures of output do Haile et al. use? Why?
    - What level of aggregation do they use for measuring output? Why?
    - What are limitations to their measures or the level of aggregation?
3. Supply models
    - What supply model do they use and why?
4. Empirical model and identification concerns
    - What empirical model do they use and why?

Haile et al. (2016) Measures of Output

1. acreage (Coyle 1993; Haile, Kalkuhl, and von Braun 2014)
2. yield (Weersink, Cabas, and Olale 2020)
3. total production (Coyle 1999)
4. total caloric production (caloric value of total production) (Roberts and Schlenker 2009 and 2013)
5. crop cuts (Gourlay, Kilic, and Lobell 2017)

- What measures of output do Haile et al. use? Why?
- What level of aggregation do they use for measuring output? Why?
- What are limitations to their measures or the level of aggregation?

Haile et al. (2016) Models of Supply

Haile et al. summarize two possible supply models (to model annual crop production):

1. Nerlovian partial adjustment framework
2. "Supply function approach" (supply response derived from the profit-maximizing problem)

- Which model does Haile et al. employ? Why?
- What changes or improvements do they make to the model?

Haile et al. (2016) Models of Supply

$$Q_t^d = \beta_1 + \beta_2 p_t^e + \beta_3 Z_t + \epsilon_t \tag{1}$$

$$Q_t^d = \beta_1 + \beta_2 \eta p_t^{e,int} + \beta_3 Z_t + \epsilon_t \tag{1'}$$

$$A_t^d = \alpha_1 + \alpha_2 p_t^e + \alpha_3 Z_t + \epsilon_t \tag{2}$$

$$A_t^d = \alpha_1 + \alpha_2 \eta p_t^{e,int} + \alpha_3 Z_t + \epsilon_t \tag{2'}$$

Haile et al. (2016) Econometric Model

$$
\begin{aligned}
Q_{itk} = &\pi_1 Q_{ikt-1} + \sum_{j=1}^{4} \alpha_{ij} p_{jkt_{ik}} + \sum_{j=1}^{4} \phi_{ij} vol(p)_{jkt_{ik}} \\
&+ \lambda_{i1} w_{ikt_{ik}} + \lambda_{i2} YS_i kt_{ik} + \mu_{it} + \eta_{ik} + \mu_{ikt}
\end{aligned} \tag{3}
$$

- How does the model incorporate uncertainty in prices?
- How can we interpret α_{ij}?
- Which parameter(s) represent Z_t in the conceptual model?
- Why are there subscripts on the subscript t for some variables?
- How does this model differ from the yield response model?
- Why can this not be estimated with OLS?

Haile et al. (2016) Econometric Model: System GMM

The authors summarize two potential GMM methods for estimating this equation:

1. Difference GMM – transform all regressors by first differencing, then estimate using GMM (Arellano and Bond, 1991)
2. System GMM – assume the first difference of instruments are uncorrelated with fixed effects, then can instrument $y_{i,t-1}$ with $\Delta y_{i,t-2}$ (Blundell and Bond, 1998)

Haile et al. (2016) Econometric Model: System GMM

Haile et al. use system GMM, some properties are:

- OLS and FE estimates should bound these estimates. If OLS lagged dependent variable is positively correlated with the error term, then after adding a FE or first differencing, the variable is negatively correlated with the error term. $\leftarrow$ note really only matters in small samples. Judson & Owen (1999) find a bias of 20% of the coefficients of interest when T=30 (number of time periods)
- If OLS and FE do not bound the estimate, indicates specification issues
- Errors cannot be serially correlated and assumes that first differences of instruments are uncorrelated with fixed effects (here country-by-year and country-by-crop)

Haile et al. (2016) Results

Table 2. Estimates of Production and Acreage Response

	Production				Acreage			
Variable	*Wheat*	*Corn*	*Soybeans*	*Rice*	*Wheat*	*Corn*	*Soybeans*	*Rice*
Lagged dep. var.	0.961***	0.964***	0.928***	0.625***	0.990***	0.978***	0.932***	0.747***
	(0.013)	(0.030)	(0.036)	(0.089)	(0.005)	(0.033)	(0.029)	(0.045)
Lagged dep. var. (2)				0.356***				0.244***
				(0.099)				(0.039)
Wheat price	0.106**	−0.015	−0.205***		0.075***	0.009	−0.034***	
	(0.046)	(0.057)	(0.058)		(0.027)	(0.014)	(0.012)	
Corn price	0.034	0.226**	−0.054		−0.002	0.069***	−0.118***	
	(0.052)	(0.113)	(0.066)		(0.032)	(0.025)	(0.025)	
Soybean price	−0.028	0.050	0.365**		−0.047	−0.038*	0.146**	
	(0.054)	(0.062)	(0.166)		(0.029)	(0.020)	(0.074)	
Rice price	−0.020	−0.135**	−0.061	0.058***				0.024**
	(0.023)	(0.068)	(0.065)	(0.025)				(0.010)
Wheat price volatility	−0.628**	0.074	0.511***		−0.350***	0.123	−0.110	
	(0.281)	(0.283)	(0.162)		(0.124)	(0.146)	(0.151)	
Corn price volatility	0.159	0.287	−0.374**		0.249*	0.135	0.134	
	(0.438)	(0.252)	(0.175)		(0.123)	(0.095)	(0.147)	
Soy price volatility	0.366	−0.608	0.013		0.279**	−0.108	0.228**	
	(0.234)	(0.559)	(0.411)		(0.106)	(0.128)	(0.092)	
Rice price volatility				−0.197**				−0.064
				(0.106)				(0.062)
Fertilizer price	−0.068**	−0.010	0.040**	−0.014	−0.013	−0.017	0.013	−0.003
	(0.023)	(0.018)	(0.018)	(0.019)	(0.011)	(0.014)	(0.029)	(0.013)

Haile et al. (2016) Results

Table 3. Estimates of Yield Response

Variable	*Wheat*	*Corn*	*Soybeans*	*Rice*
Lagged dep. var.	0.920***	0.960***	0.925***	0.724***
	(0.032)	(0.020)	(0.034)	(0.133)
Lagged dep. var. (2)				0.272
				(0.165)
Own-crop price	0.166***	0.094**	0.146***	0.043**
	(0.055)	(0.039)	(0.045)	(0.018)
Own-price volatility	−0.336**	−0.366**	−0.467**	−0.148**
	(0.168)	(0.170)	(0.226)	(0.070)
Fertilizer price	−0.069**	−0.008	−0.050**	−0.020
	(0.026)	(0.021)	(0.020)	(0.017)
Time dummies	Yes	Yes	Yes	Yes
N	1,174	1,444	1,371	1,332
F-test of joint significance: *p*-value	0.000	0.000	0.000	0.000
Test for AR(1): *p*-value	0.002	0.001	0.000	0.016
Test for AR(2): *p*-value	0.046	0.425	0.079	0.574
Diff-in-Hansen test: *p*-value	0.950	0.749	0.933	0.751

Haile et al. (2016) Results

Table 4. Standardized Effect Sizes of Price and Volatility on Supply for Each Crop

	Wheat price	Corn price	Soybean price	Rice price	Wheat price volatility	Corn price volatility	Soy price volatility	Rice price volatility	Fertilizer price
Production response									
Wheat	**0.045**	0.012	0.011	−0.008	**−0.025**	0.005	0.016		**−0.044**
Corn	−0.005	**0.061**	0.015	**−0.042**	0.002	0.006	−0.019		−0.005
Soybeans	**−0.065**	−0.015	**0.108**	−0.019	**0.016**	**−0.008**	0.000		**0.020**
Rice				**0.021**				**−0.008**	−0.008
Acreage response									
Wheat	**0.035**	−0.001	−0.020		**−0.015**	**0.008**	**0.013**		−0.009
Corn	0.004	**0.025**	**−0.015**		0.005	0.004	−0.005		−0.011
Soybeans	**−0.013**	**−0.040**	**0.053**		−0.004	0.003	**0.009**		0.008
Rice				**0.010**				−0.003	−0.002
Yield response									
Wheat	**0.132**				**−0.025**				**−0.084**
Corn		**0.054**				**−0.016**			−0.009
Soybeans			**0.109**				**−0.037**		**−0.062**
Rice				**0.038**				**−0.015**	−0.028

Note: The effect sizes that are statistically significant at the 10% level or less are typed in bold.

Haile et al. (2016) Simulation Results

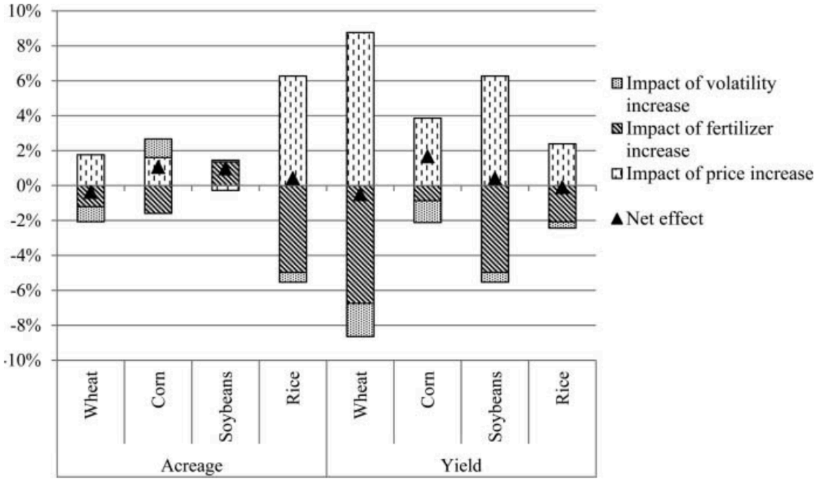

Figure 1. Impacts of the 2006–2010 price dynamics on acreage and yield

Haile et al. (2016) Simulation Results

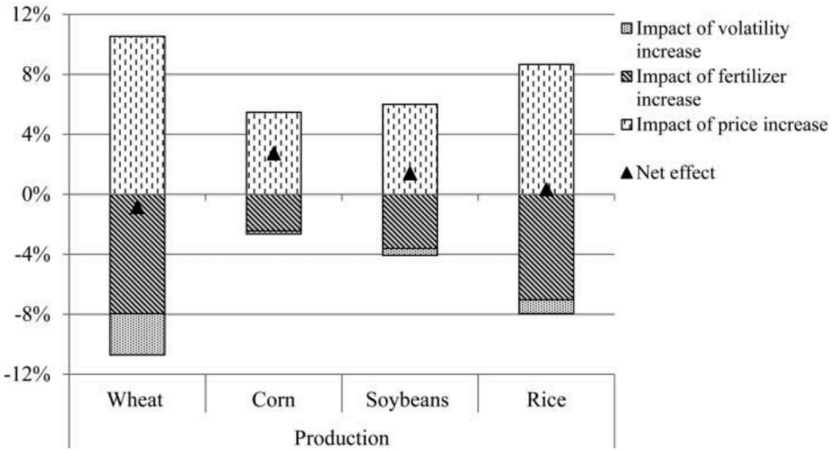

Figure 2. Impacts of the 2006–2010 price dynamics on production

Note: See simulation assumptions detailed in figure 1.

Reading for Next Time

Chavas, J.P. & Holt, M.T. (1990). Acreage Decisions Under Risk: The Case of Corn and Soybeans. *American Journal of Agricultural Economics, 72(3)*: 429-538. `https://www.jstor.org/stable/1243021#metadata_info_tab_contents`

Just, D.R., Khantachavana, S.V., & Just, R.E. (2010). Empirical Challenges for Risk Preferences and Production. *Annual Review of Resource Economics, 2*: 13-31. `https://www.annualreviews.org/doi/abs/10.1146/annurev.resource.012809.103902?journalCode=resource`

Just et al. (2010) Overview

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Contributions – what question(s) is the paper addressing? –

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Just et al. (2010) – Common Empirical Questions Related to Risk

1. Effect of price risk on production
2. Effect of price risk on input choices and use
3. Linking risk preferences to demographic and socioeconomic characteristics
4. Testing for different types of risk aversion (decreasing absolute and increasing relative risk aversion)
5. Examining role and effects of risk mitigation strategies (e.g. insurance, hedging, and input choice)

Which of these categories does Haile et al. fall into?

Which of these categories does the Chavas & Holt paper fall into?

Just et al. (2010) – Five Reasons Analyses of Risk are Challenging

1. Determining the decision model
2. Separate identification of covariates with risky behavior (e.g. firm size)
3. How to model wealth
4. Identification and separation of risk perceptions and risk preferences
5. Degree of flexibility of functional forms

Just et al. (2010) – A Model of Producer Decision-making under Risk

Producers maximimize **Expected Utility:**

$$\max_{\mathbf{x}}\{E[U(w+\pi|\theta)]|\pi=\mathbf{p}\cdot\mathbf{f}(\mathbf{x},\epsilon|\gamma)-\mathbf{r}\cdot\mathbf{x},\phi,\bar{\omega}\}$$

where w is initial wealth,

θ is the risk preference parameter,

$\mathbf{x}$ is a vector of inputs with associated prices $\mathbf{r}$,

$\mathbf{p}$ is a vector of output prices with distribution parameters ϕ,

ϵ is a random disturbance with distribution parameters $\bar{\omega}$,

and γ are parameters for the production function.

What term represents *production uncertainty*?

price uncertainty?

technological uncertainty?

Just et al. (2010) – Estimating the Maximization Problem

(Structurally) Estimating the producer maximization problem requires four equations:

1. Utility of wealth
2. Non stochastic production function
3. Stochastic structure of production function
4. Distribution of prices

Just et al. (2010) – Estimating the Maximization Problem

Holt & Chavas (2002) provide an overview of common empirical methods to estimating this problem.
The main reduced form estimating equation can be written as:

$$y = b_0 + b_1 \bar{p} + b_2 \sigma_p^2 + b_3 w_0 + \mathbf{c}^\mathsf{T} \mathbf{r}$$

Where w_0 is often dropped from the model due to missing data, or by assuming CARA.

When instead modeling acreage, consider that production is defined as $y = aq$, so that the production equation can be rewritten by considering revenue per acre rather than output prices, and thus σ_p^2 represents the variance of revenue per acre rather than prices.

$$a = \beta_0 + \beta_1 \bar{p} + b_2 \sigma_p^2 + \gamma^\mathsf{T} \mathbf{r} + \varepsilon$$

Note that this can be extended to a multiple-equation reduced form by modifying the single equation approach to include a vector of acreage, prices, etc. (using SUR)

Just et al. (2010) – Estimating the Maximization Problem

Holt & Chavas (2002) provide an overview of common empirical methods to estimating this problem.

In estimating the reduced form equations, they suggest the Generalized Autoregressive Conditional Heteroskedasticity Model (GARCH): (from Bollerslev, 1986).

$$GARCH(p,q) \Rightarrow \sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i e_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-i}^2$$

$$e_t \sim N(0, \sigma_t^2)$$

$$\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j < 1$$

where e_t comes from $p_t = \lambda \sum_{i=0}^{\infty} (1-\lambda)^i p_{t-i-1} + e_t$.

Just et al. (2010) – Estimating the Maximization Problem

The most commonly applied model is GARCH(1,1), which yields the estimating equation:

$$a_t = \beta_0 + \beta_1(\delta_0 + \Phi_1 p_{t-1} + ... + \Phi_k p_{t-k} + \beta_2(w_0 + \alpha_1 e_{t-1}^2 + \gamma_1 \sigma_{pt-1}^2) + \zeta^T r_t + \varepsilon_t$$

where Φ is a lag operator.

Just et al. (2010) – Challenges in Existing Empirical Work

1. Wealth and Risk Aversion
2. Dynamics and Risk
3. Addressing Identificaiton

What are their suggestions moving forward?

Chavas and Holt (1990) Overview

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