Invited presentation at the 2018 Southern Agricultural Economics Association Annual Meeting, February 2-6, 2018, Jacksonville, Florida

Deriving Theoretically Sound Price Series for Hypothetical Futures Contracts

Robert Thompson
Ardian Harri, PhD
Joshua Maples, PhD
Eunchun Park, PhD

MISSISSIPPI STATE UNIVERSITY
Department of Agricultural Economics

Introduction

- Futures contracts are tied to a spot price
- Use of marketing arrangements change
- Change futures contract to align with marketing arrangements
  - Example:

Live Hog Futures	→	Lean Hog Futures
Live pricing		Carcass pricing

Introduction

- What if we could derive the new futures contract term structure before it was implemented?

Previous Research

- Schroeder and Yang (2001) and Mattos et al. (2003)
  - Boxed Beef Cutout Value (BBCV) futures
  - Hedging wholesale beef cuts
- Assumed nearby BBCV futures contract price equivalent to BBCV index
  - Assumption is not theoretically sound

Our Contribution

- Develop methods that derive theoretically accurate hypothetical futures contract
- Useful in evaluating contract effectiveness before they are implemented

Conceptual Framework

1. Estimate relationship between spot price and futures price for the existing futures contract
2. Apply that relationship to a different spot price

Conceptual Framework

- Schwartz and Smith (2000) futures valuation model

$$\ln(S) = \chi_t + \xi_t$$

$$d\chi_t = \left(-\kappa\chi_t - \lambda_\chi\right)dt + \sigma_\chi dz_\chi$$

$$d\xi_t = \left(\mu_\xi - \lambda_\xi\right)dt + \sigma_\xi dz^*_\xi$$

$$dz^*_\chi dz^*_\xi = \rho_{\chi\xi}dt$$

Conceptual Framework

- Schwartz and Smith (2000) futures valuation model

$$\ln\left(F_{T,0}\right) = e^{-\kappa T}\chi_0 + \xi_0 + A(T)$$

$$A(T) = \mu_\xi^* T - \left(1 - e^{-\kappa T}\right)\frac{\lambda_\chi}{\kappa} + \frac{1}{2}\left(\left(1 - e^{-2\kappa T}\right)\frac{\sigma_\chi^2}{2\kappa} + \sigma_\xi^2 T + 2\left(1 - e^{-\kappa T}\right)\frac{\rho_{\chi\xi}\sigma_\chi\sigma_\xi}{\kappa}\right)$$

$$\mu_\xi^* = \mu_\xi - \lambda_\xi$$

Conceptual Framework

- Apply the model to new spot price

$$\ln\left(S_t^H\right) = \chi_t^H + \xi_t^H$$

- χ_t gives price deviations from short term supply/demand shocks
- Assume $\chi_t^H \approx \chi_t$
  - Prices are for same commodity – short term supply/demand shocks are equivalent

Conceptual Framework

- Convert short term deviation to a percentage of spot price and apply it to the new spot price

$$\chi_t^H = \ln\left(S_t^H\right)\left(\frac{\chi_t}{\ln S_t}\right)$$

$$\xi_t^H = \ln\left(S_t^H\right) - \chi_t^H$$

Conceptual Framework

- Use κ, λ_χ, σ_χ, and $\rho_{\chi\xi}$ from existing futures parameter estimates

$$d\chi_t = \left(-\kappa\chi_t - \lambda_\chi\right)dt + \sigma_\chi dz_\chi$$

- Use $\mu_{H\xi}$, $\lambda_{H\xi}$, and $\sigma_{H\xi}$ from new spot price parameter estimates

$$d\xi_t^H = \left(\mu_{H\xi} - \lambda_{H\xi}\right)dt + \sigma_{H\xi} dz_\xi^*$$

Conceptual Framework

- Hypothetical futures generation model

$$\ln\left(F_{T,t}^{H}\right)=e^{-\kappa T}\chi_{t}^{H}+\xi_{t}^{H}+A^{H}\left(T\right)$$

$$A^{H}\left(T\right)=\mu_{H\xi}^{*}T-\left(1-e^{-\kappa T}\right)\frac{\lambda_{\chi}}{\kappa}+\frac{1}{2}\left(\left(1-e^{-2\kappa T}\right)\frac{\sigma_{\chi}^{2}}{2\kappa}+\sigma_{H\xi}^{2}T+2\left(1-e^{-\kappa T}\right)\frac{\rho_{\chi\xi}\sigma_{\chi}\sigma_{H\xi}}{\kappa}\right)$$

$$\mu_{H\xi}^{*}=\mu_{H\xi}-\lambda_{H\xi}$$

Empirical Methods

- Schwartz and Smith (2000) model
  - State-space model
  - Kalman Filter and Maximum likelihood estimation
  - AKA Prediction Error Decomposition
- New spot price parameters
  - Single equation Brownian motion

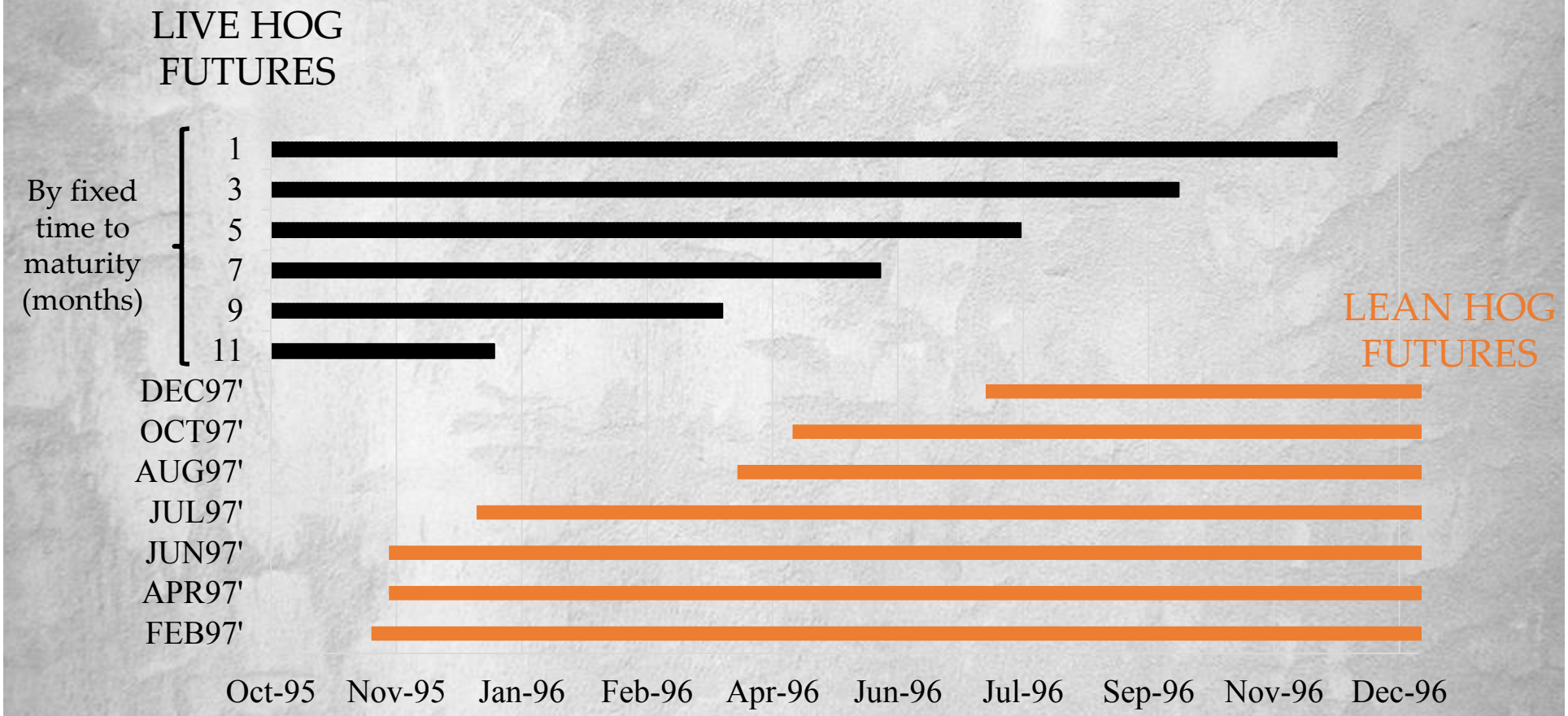
Data

- Weekly prices
- Live Hog futures and Omaha live price from Dec-1984 to Nov-1996
- Lean Hog futures from Nov-1995 to Nov-1996
- Lean Hog index from Nov-1995 to Nov-1996

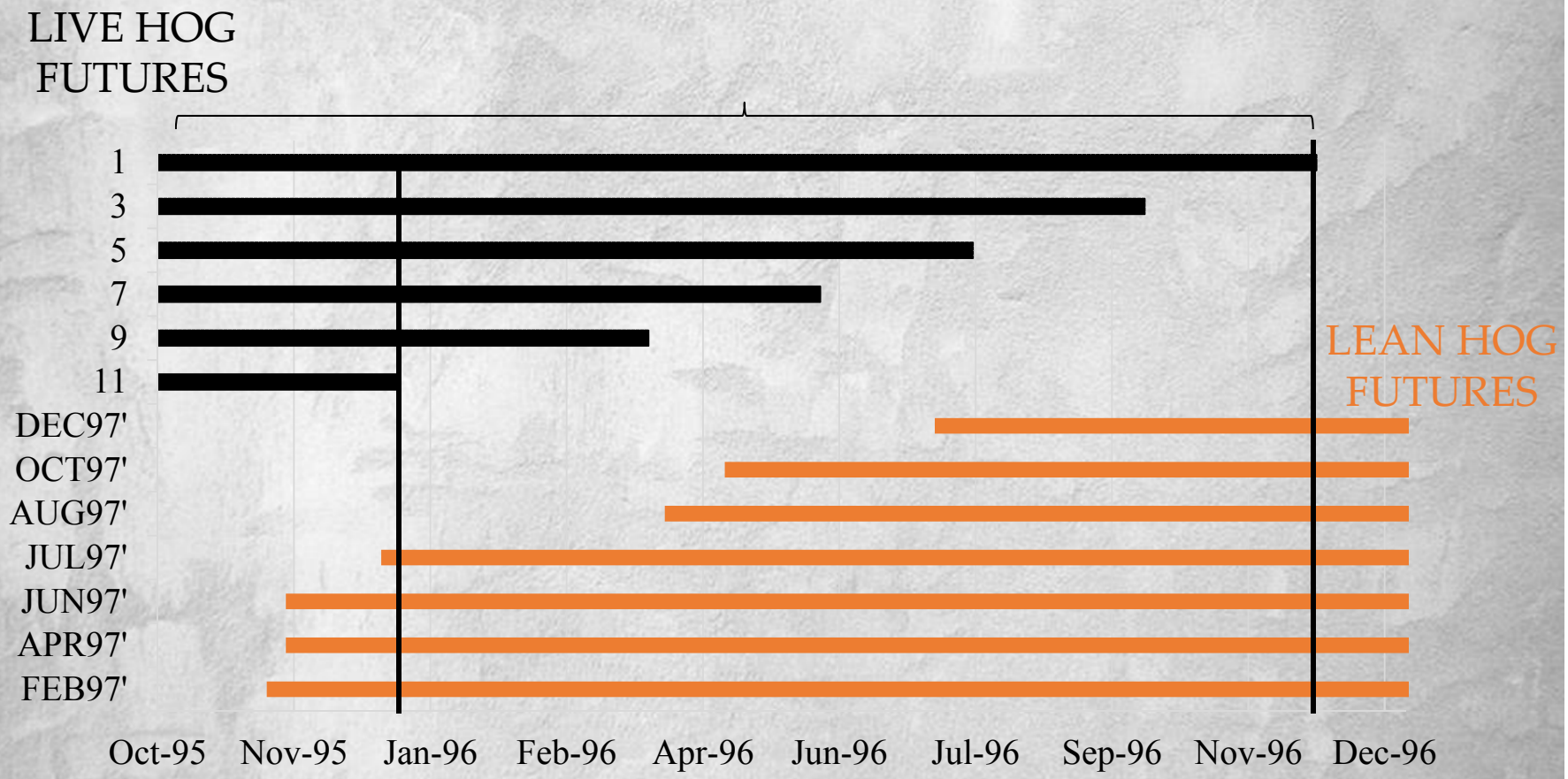
Empirical Application

- Live Hog contract (Live price) replaced by Lean Hog Contract (Carcass price) with February 1997 contract
- Between 1995 and 1997 both Live and Lean contract trading at the same time

Lean-Live Hog futures overlap



Lean-Live Hog futures overlap



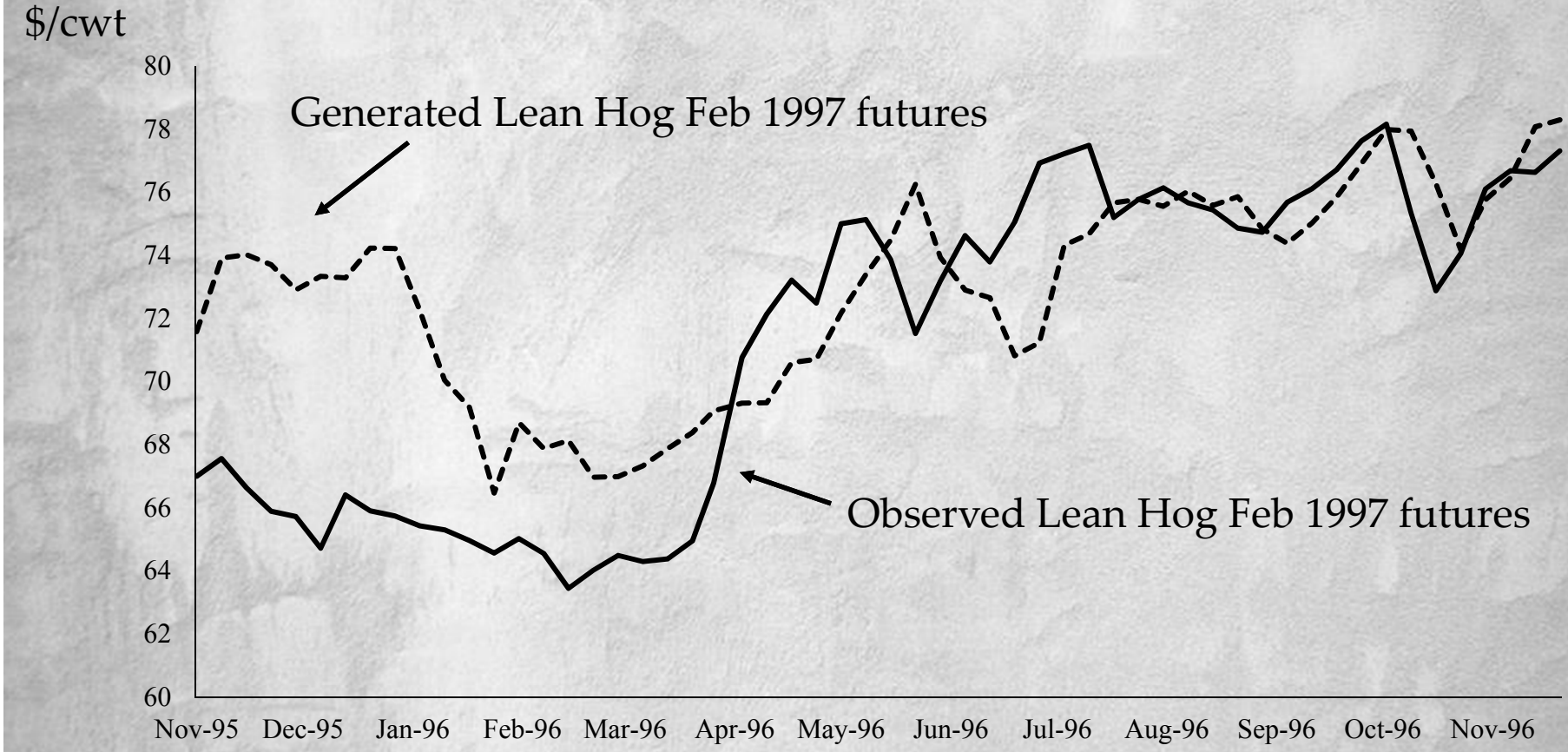
Empirical Application

- Generated Live Hog futures
- Compared to observed Live Hog futures prices to get a base model error
- Generated Lean Hog futures prices
- Compared to observed Lean Hog futures prices

Empirical Application

- Calculated Root Mean Square Errors (RMSE) of generated prices to observed prices
- Calculated RMSE for each futures contract

Results


$/cwt
80
78
76
74
72
70
68
66
64
62
60
Generated Lean Hog Feb 1997 futures
Observed Lean Hog Feb 1997 futures
Nov-95
Dec-95
Jan-96
Feb-96
Mar-96
Apr-96
May-96
Jun-96
Jul-96
Aug-96
Sep-96
Oct-96
Nov-96

Results

Live Hog Futures

	Feb	Apr	Jun	Jul	Aug	Oct	Dec
RMSE	1.29	1.97	3.53	3.38	2.10	2.47	1.57

Results

Lean Hog Futures

	Feb-97	Apr-97	Jun-97	Jul-97	Aug-97	Oct-97	Dec-97
RMSE	3.86	4.91	3.85	3.28	4.45	8.90	8.58

Conclusions and Implications

- Our methods perform well for Lean Hog futures
- We can apply these methods to similar futures contracts

Future Research

- Add seasonal component to model
- Apply methods to Live Cattle futures contract
- Generate Boxed Beef Cutout value futures contract
- Evaluate effectiveness of Boxed Beef Cutout value futures contract for risk management purposes

Thank you
Questions?