Energy Price Uncertainty and Global Land Use

Alla Golub (Purdue University)
golub@purdue.edu

Yongyang Cai (UC Chicago and Hoover Institution)
yycai@stanford.edu

Thomas Hertel (Purdue University)
hertel@purdue.edu

Jevgenijs Steinbuks (World Bank)
steinbuk@gwmail.gwu.edu

Selected Poster prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Joint Annual Meeting, San Francisco, CA, July 26-28.

Energy Price Uncertainty and Global Land Use

Alla Golub[1], Yongyang Cai[2], Thomas Hertel[1], Jevgenijs Steinbuks[3]
1 Purdue University, 2 University of Chicago & Hoovers Institution, 3 World Bank

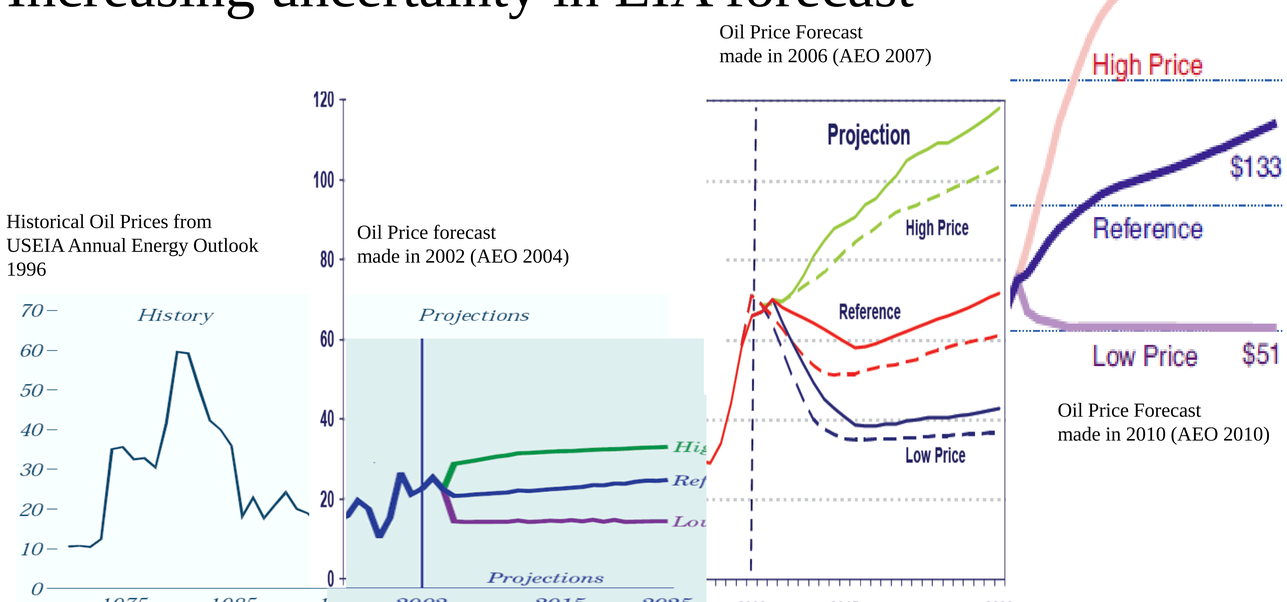
Motivation

- Petroleum and natural gas prices are key factors affecting competitiveness of biofuels and cost of fertilizer
- Rising energy prices put significant pressure on global land supply and greenhouse gas emissions from terrestrial systems
- The effect of uncertainty in energy prices on global land use dominates the effects of (1) uncertainty in energy and climate mitigation policies and (2) uncertainty in climate impacts (Steinbuks and Hertel 2013)
- Uncertainty in energy prices has received relatively little attention in the literature concerning land use

Characterizing uncertainty in energy prices

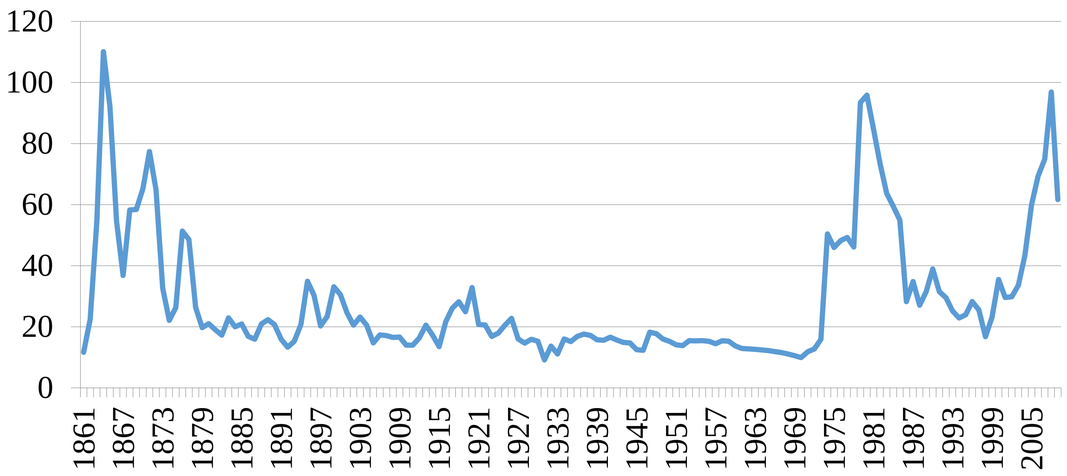
- Sources of uncertainty
  - Technology and discovery
  - Economics and behavior of oil producers and consumers
- Available information
  - U.S. EIA Annual Energy Outlook includes alternative oil price cases from 2010 to 2040
  - History

Increasing uncertainty in EIA forecast



Source: Steinbuks 2013

Historical crude oil prices, 2009 $US/barrel

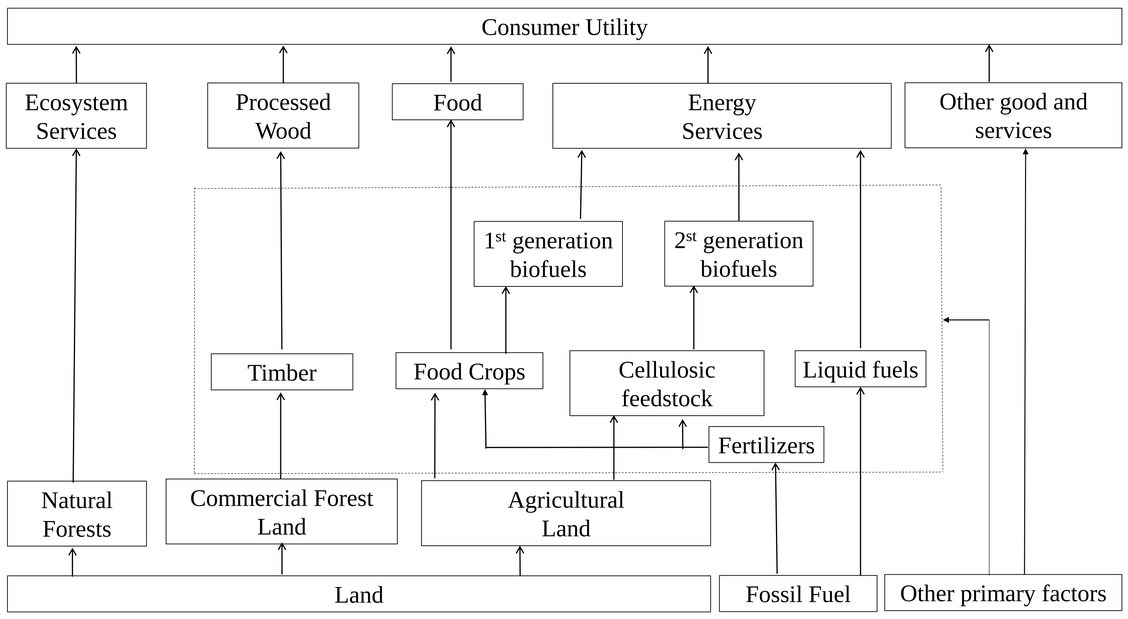


ChartsBin statistics collector team 2014, *Historical Crude Oil prices, 1861 to Present*, ChartsBin.com, viewed 14th February, 2014, <http://chartsbin.com/view/oau>.

AR(1) model: $\ln(p^*_t) = \rho \ln(p^*_{t-1}) + \varepsilon_t$, $\rho = 0.772$,

p-value ≤ 0.05, *p* is normalized price (Pindyck 1999)*

A Global PE Model of Land Use (FABLE)



Model description

- Economy representation similar to FABLE model (Cai et al. 2014)
- Stochastic dynamic
- Energy price is exogenous
- Vintage Representation of Forestry Sector
- Intensification in crops and cellulosic feedstock production
- 1st and 2nd Generation Biofuels
- Calibrated to 2004 data (FAO, GTAP)

Implementation

- Dynamic programing method
- Energy price follows AR(1) with exogenous jump process
- Solve maximization problem

$$V(X, p) = \max_C \{U(C) + \beta E[V(X^+, p^+) \mid p]\}$$

$$E[V(X^+, p^+) \mid p] = \int_0^\infty V(X^+, p^+) f(p^+ \mid p) dp^+$$

- Replace the continuous-valued Markov chain with a finitely-many-discrete-valued Markov chain (Tauchen 1986)
- The values of Markov chain are chosen using the scheme described in Cai et al. (2014a)
- Find value function and policy rules for deterministic problems
- Employ the stochastic dynamic programming structure described in Cai and Judd (2014) and its parallel algorithms described in Cai et al. (2014c) to determine impact of uncertainty on optimal path of land use

References

Cai, Y., and K.L. Judd (2014). "Advances in numerical dynamic programming and new applications." Chapter 8 in *Handbook of Computational Economics*, Volume 3, edited by Karl Schmedders and Kenneth L. Judd.

Cai, Y., K.L. Judd, and T.S. Lontzek (2015a). "The social cost of carbon with economic and climate risks." Under review of Journal of Political Economy, arXiv preprint arXiv:1504.06909.

Cai, Y., K.L. Judd, and J. Steinbuks (2015b). "A nonlinear certainty equivalent method for dynamic stochastic problems." Under review of Quantitative Economics.

Cai, Y., K.L. Judd, G. Thain, and S. Wright (2015c). "Solving dynamic programming problems on a computational grid." Computational Economics, 45(2), 261-284.

Cai, Y., J. Steinbuks, J. Elliot, and T. Hertel (2014). "The effect of climate and technological uncertainty in crop yields on the optimal path of global land use". World Bank Policy Research Paper 7009.

Pindyck, 1999. "The long-run evolution of energy prices". *The Energy Journal* 20(2).

Steinbuks, J. and T. Hertel. 2013. "Energy Prices Will Play an Important Role in Determining Global Land Use in the 21st Century", *Environmental Research Letters* 8(1), article 014014.

Tauchen, George. 1986. "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions" *Economic Letters.* 20: 177–181.