Analysis of agricultural trade under climate change in a stochastic dynamic control context

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Background

- Broadacre agriculture in Australia primarily wheat and other extensive crops, sheep and beef.
  - Likely to have a comparative advantage in these products
  - Land intensity of production makes broadacre more vulnerable than intensive farming systems to adverse climate change
  - Output tied to vagaries of rainfall – Australian rainfall highly variable – likewise agricultural output
- Majority of which is produced in areas of Australia that are predicted to be most adversely impacted by climate change

Background

- Agriculture presents a problem for trade analysis
  - Fluctuations in global agricultural yields and government interventions mean that trade patterns of agricultural goods in a short period of time reflect the underlying comparative advantage less than we would expect for other goods.
  - Several features unique to the agricultural sector complicate the application of conventional models of trade, not least of which is the stochastic nature of rainfall

Research questions

- Is there a role for explicitly considering agricultural production uncertainty?
  - Production uncertainty has implications for long-term investment decisions and the dynamics of agricultural comparative advantage
  - The relationship between this production uncertainty and the patterns of agricultural trade not yet investigated in the literature.
- What is the relationship between the uncertainty in agricultural output and trade vis-à-vis comparative advantage?
  - What implications does this have for climate change?

Developing a framework

- Process
  - Develop a framework to analyse investment decisions in agriculture under uncertainty
  - Use implications as a feedstock in a model of international trade
  - Use the above to examine that agricultural trade implications of climate change

Developing a framework

- What features?
  - Static vs dynamic
    - Dyanmics require optimal control methods
  - Deterministic vs Stochastic
- Stochastic optimal control
  - Ito stochastic calculus appears to provide a good pathway to an answer

Conceptual framework

- Specific-factors, with two sectors and three factors

- Agricultural output is generated from a combination of capital and land endowments, by the stochastic process

$$Y_1(T, K_1) + \sigma_Y(T, K_1)\varepsilon_T$$

- The non-agricultural good is deterministic, and uses capital and labour

$$Y_2(K_2, L)$$

Conceptual framework

- Output is consumed or saved, savings are consolidated then apportioned out to sectors as investment capital
- Social planner seeks to maximise infinite horizon utility subject to some stochastic wealth accumulation condition

$$V\{W,t,\infty\} = \max_{\varphi,c_1,c_2} E_t \int_t^{\infty} e^{-\rho t} U\{C_1,C_2\} dt$$

s.t.

$$dW = \{s_1 Y_1(T,K_1) + s_2 Y_2(L,K_2)\}dt + s_1 \sigma_Y(T,K_1) dS$$

Propositions

- **1**: Risk aversion implies that increasing uncertainty in the output of the uncertain good (agriculture) reduces - the share of wealth invested in agriculture

$$\varphi = \frac{s_1 y_1(\tau) - s_2 y_2(l)}{\frac{-J_{WW}}{J_W} W\{s_1 \sigma_y(\tau)\}^2}$$

Propositions

- **2**: Risk aversion implies that increasing output uncertainty in the output of the agricultural good acts to increase the marginal utility of consumption of the agricultural good relative to that of the non-agricultural good

$$\frac{\partial U}{\partial C_2} = \frac{\partial U}{\partial C_1} + \frac{s_1 J_{WW} \varphi W \{\sigma_y(\tau)\}^2}{y_1(\tau)}$$

Conceptualising trade implications

- Special case where two countries are identical in all aspects (preferences, endowments, technology) except their degree of uncertainty
  - Allows us to examine the role of uncertainty in comparative advantage in isolation
- Assume that one country has more uncertain production conditions than the other

Preliminary trade pattern propositions

- **3**: Assuming competitive markets, and risk aversion, in autarky the price of the agricultural good will be greater than the price of the non-agricultural good

$$P_2 = P_1 + \frac{s_1 J_{WW} \varphi W \{\sigma_y(\tau)\}^2}{y_1(\tau)}$$

Also, the country which experiences the greater degree of uncertainty, in autarky will have the highest price for the agricultural good, and the lowest price for the non-agricultural good.

Preliminary trade pattern propositions

- **4**: Uncertainty in production acts as a source of comparative disadvantage, when the degree of uncertainty is greater than that of other potential producers
  - Relatively smaller share of accumulated wealth directed to agriculture → lower output
  - Also, relatively slower rate of accumulation of agricultural capital

Preliminary trade pattern propositions

- **5**: Differential impacts of climate change with respect to agricultural uncertainty (risk) may
  - Reinforce existing patterns of comparative advantage
    - The risky become riskier
  - Diminish the strength of those patterns,
    - Risk gap is narrowed
  - Or, potentially reverse the patterns of advantage
    - Least risky become most risky

Australian context

- Production uncertainty appears to have influenced development of broadacre production systems
- Increasing uncertainty with climate change likely to reduce growth of agricultural capital stock
  - Decreasing long-run average output?
  - Decreasing long-run agricultural exports?

Future directions

- Role of endowment abundance/scarcity patterns with uncertainty
  – Australia posses a large endowment of land, but also a high degree of production uncertainty

- Climate change likely to impact upon both arable land endowment and degree of production uncertainty