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China's Agriculture under Urbanization: A Partial Equilibrium Analysis

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Introduction

Rapid urbanization is expected to have implications for China's food security – among many other factors, rural labor migration and potential barriers to substituting capital for labor in China's agricultural sector will make it challenging to maintain food security for a large and growing population.

Though rural labor is widely considered to have a surplus, adequate future rural labor availability cannot be taken for granted – concerns over farming labor's availability, and the age and gender structure of this labor are raised and discussed in recent literature.

Accompanying the decline in farming labor availability is an ongoing substitution of capital for labor. However, the utilization of more capital could be relatively investment-intensive; marginal returns to capital may be decreasing as farming becomes more capital-intensive. The economies of scale associated with using mechanical power may not be easily achieved.

Simply put, the growing urban population, shifting diet composition, urbanization-induced changes in farming labor and the potential barriers to substituting capital for labor will impose increasing pressure on China's food security.

Research Objective

This study developed a partial equilibrium model of China's agricultural sector, focusing on crops, to investigate the potential effects of the structural changes mentioned above.

Methodology – Model Development

The newly developed China agricultural sector model (China-ASM) follows the essential structure of the U.S. Forest and Agricultural Sector Optimization Model (US-FASOM) (see Schneider et al. 2007 for a brief introduction). The current version of China-ASM is designed to simulate crop production decision-making at the province level in China, along with the aggregate impacts of those decisions on national markets.

The China-ASM depicts the following key components of the China crop production sector: land, labor, and resources endowments, agricultural factor markets, agricultural production budgets, and crop commodity markets.

The China-ASM portrays representative crop producers at the province level, where province-specific agricultural production budgets are incorporated through Leontief production possibilities, which specify fixed quantities of inputs and outputs associated alternative management strategies that can be employed.

Mathematical Structure

$$\begin{aligned}
 (1) \quad & \max \sum_{i=1}^I p_i(Z_i) M_i - \sum_{j=1}^J p_j(X_j) M_j \\
 (2) \quad & s.t. \quad Z_i \\
 (3) \quad & - \quad X_j \\
 (4) \quad & \sum_{i=1}^I p_i(Z_i) M_i \leq Y_{ij}, \forall j \\
 (5) \quad & Z_i, \quad X_j, \quad Q_{ik} \geq 0, \quad \forall i, k, \beta, k
 \end{aligned}$$

h indexes commodity Z (crop: corn, rice, wheat, etc.)
 i denotes input X : capital, land, and labor.
 β represents region (province) and k indexes process Q (crop budget).
 Y refers to resources endowments.
 P represents the inverse demand/supply functions.

Mathematical Structure Description

The objective function (1) is to maximize the consumer and producer welfare in the crop market sector. The decision variables include crop producers' decisions on how to allocate sown area/cropland across different crops, given the technical, environmental, and resources constraints [as depicted by equations (2) – (4)], as well as market conditions they are facing. Variation in crop production activities across provinces/regions are thus endogenously determined by the optimization model.

Data Sources

China Agricultural and Economic Data (English), compiled by USDA Economic Research Service

- China National Bureau of Statistics
- China Ministry of Agriculture
- cropland base, sown area, crop production and derived crop yield

China Agricultural Statistical Yearbook 2006 (Chinese), China Ministry of Agriculture

- capital, labor, wholesale price, and derived region-specific crop budget

Demand Elasticity Studies for China Published Since 2005, in Thompson and Abler (2010)

- crop market parameters

The China-ASM base model is calibrated to the 2005 market conditions.

Scenario Development

Monchuk et al. (2010) examined production inefficiency associated with the rural labor surplus in China's agriculture. Wang (2010)'s research however suggested that China has reached the Lewis turning point (LTP) in its rural farming labor sector, indicating that the labor surplus is no longer the case. Whether there's a surplus of farming labor in today's China is out of the scope of this study, but these two papers provide alternative labor scenarios used for this study.

Li et al. (2013) and Huang et al. (2009) examined the phenomenon of "moving off the farm and intensifying agricultural production." Though capital could substitute for labor in agricultural production, there are barriers to utilizing more capital inputs. For example, Wu et al. (2005) pointed out that the barriers to extensive use of machinery in China's agriculture are substantial.

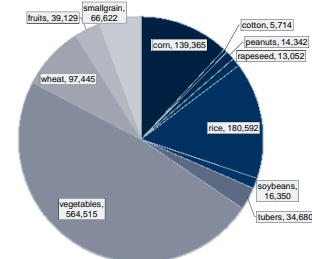
Give the above, the scenarios describing the varying labor and capital conditions under urbanization are developed. Specifically, we have:

- a. increased use of capital inputs with decreasing, constant, and increasing marginal returns assuming different levels of limitations on substitution of capital for labor, as well as synchronized increased marginal farming labor costs
- b. increased use of capital inputs with varying marginal returns, and "lagged" increased marginal farming labor costs

The scenarios also introduce different levels of domestic demand for food and feed grains, and all of them assume that 120 million ha of farmland will be maintained.

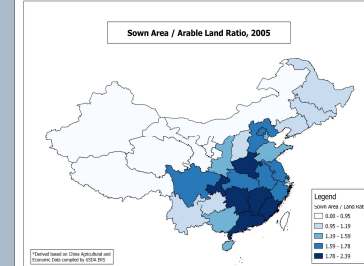
Overview of China-ASM Data (1/2)

China Crop Production in 1K Tons, 2005



*Based on China Agricultural and Economic Data compiled by Economic Research Service, USDA

Overview of China-ASM Data (2/2)



Results and Discussion

Initial model results show that despite rising production costs, the production of staple crops with relatively rigid demand (e.g., corn, rice) would expand, whereas the production of some oil crops and fruits would decrease. Total sown areas would expand also, intensifying the cropland usage.

Market-mediated outcomes such as cropland and sown area distributions across crops by province were generated, offering insights into potential changes in market equilibriums and regional cropping patterns under different marginal returns to capital/labor use scenarios.

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