Modeling Resource Allocation Decisions in the U.S. Agricultural Sector

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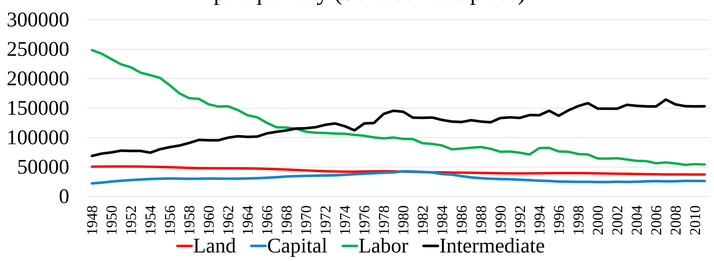
Introduction and objectives

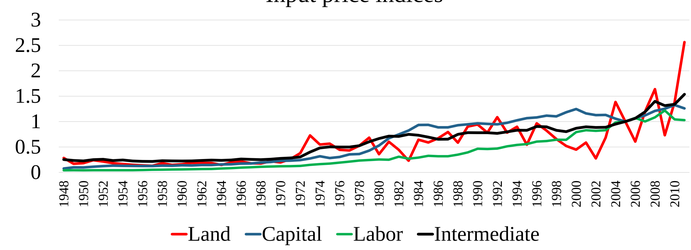
- One of the main objectives of agricultural economic research is examining the allocation of scarce resources to meet increasing food needs. Part of this allocation process relates to the decision on the choice of inputs to be used in the production of different goods. The farm's input choices are mainly driven by the output and input prices, which may be affected by agricultural policies.
- Little research has addressed how the U.S. economy as a whole allocates its resources among alternative economic activities, including food production for consumption and international trade/export activities.
- We model the U.S. agricultural sector as the producer of multiple goods and services, and we model its resource allocation decisions within a framework based on the theory of multiproduct firms.

Overview: Inputs and outputs

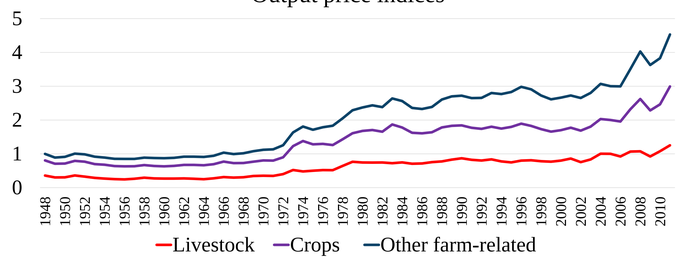
Input quantity (Service flow/price)



Input price indices



Output price indices



Model Specification

- Our starting point is Laitinen's theoretical input allocation model for the multiproduct firm:

$$f_i d\log q_i = \theta_i d(\log Q) + \gamma \sum_r g_r(\theta_i^r - \theta_i) d(\log z_r) - \psi \sum_j \theta_{ij} d(\log \frac{w_j}{W'})$$

- The empirical input allocation model can be written as (Zhu, Seale, and Onel, 2015):

$$\bar{f}_{it} dq_{it} = \theta_i DQ_t + \sum_s \overline{\pi}_{is} dp_{st} + \sum_j \tilde{\pi}_{ij} dw_{jt} + \varepsilon_{it}$$

where $dx_t = \log x_t - \log x_{t-1}$, $DQ_t = \sum_i \bar{f}_{it} dq_{it}$ is the Divisia input index, with q representing input quantity, p output price, w input price. The error term ε is normally distributed.

- Adding-up conditions: $\sum_{i=1}^{n} \theta_i = 1$, $\sum_{i=1}^{n} \overline{\pi}_{is} = 0$, and $\sum_{i=1}^{n} \tilde{\pi}_{ij} = 0$
- Homogeneity conditions: $\sum_{s=1}^{m} \overline{\pi}_{is} + \sum_{j=1}^{n} \tilde{\pi}_{ij} = 0$
- Symmetry conditions: $\tilde{\pi}_{ij} = \tilde{\pi}_{ji}$ under input-output separability
- This model does not assume input independency or input-output separability, although these conditions can be imposed.

Data

USDA/ERS, 1975-2011 (data are normalized using 2005 as the base year)	
Input variables	**Land**, **Capital** (aggregating durable equipment, service buildings, and inventories), **Labor**, and **Intermediate goods** (aggregating farm origin, pesticides, fertilizer, services, and other intermediate)
Output variables	**Livestock and products**, **crops**, **and other farm related products**

- The system was estimated by Maximum likelihood method. We assume inputs and outputs are separable so that symmetry conditions can be imposed.
- We also assume the U.S. agricultural sector is a multiproduct firm that practices joint-production.

Results

- **Table 1. Divisia Elasticity**

Land	Capital	Labor	Intermediate goods
-0.023	0.444**	0.510**	1.627***

- Divisia elasticity shows the change of the demand for a particular input when the total inputs change by 1%. The demand for intermediate goods is more responsive than the demand for other inputs with respect to a change in total inputs.
- **Table 2. Input Price Elasticities (Input-Output separability satisfied)**

	Land	Capital	Labor	Intermediate
Land	-0.008**	-0.009	-0.020*	-0.004
Capital		-0.022	-0.059	0.207*
Labor			-0.209***	0.218
Intermediate				-0.126**

- The demand for Labor is the most responsive to its own price change. Unsurprisingly, labor and land are compliments, while capital and intermediate goods are substitutes.
- **Table 3. Output price elasticity**

	Livestock and products	Crops	Other farm-related products
Land	0.020	-0.015	0.036*
Capital	-0.065	-0.097	0.048
Labor	0.001	-0.049	0.091
Intermediate goods	0.773	0.045	-0.056

- Results in table 3 show that output prices do not generally have significant effects on input demand changes, which could be attributed to the overly aggregated output variables, thus price changes of the three output variables could not effectively capture input demand changes. The exception is the case where a 1% increase in the price of other farm related goods leads to a 0.04% increase in land demand.

Conclusions

- Preliminary results show that the own input price elasticities are all negative as expected, and significant for land, labor, intermediate goods.
- Intermediate goods, capital, and labor are all complementary to land, which makes sense in the real agricultural production process.
- Intermediate goods are substitutes to capital, while labor is complementary to land.
- Due to the overly aggregated output variables, price changes of output variables do not have significant impact on the demand for inputs, except one case in which 1% price increase of other farm-related products will lead to 0.036% change in the land demand.

Contact Information

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