Space and Agriculture

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notes available online at www.econ.yale.edu/~cru2/papers.html
• Evenson and Westphal, Handbook of Development Economics, “Strong interaction between the environment and biological material makes the productivity of agricultural techniques ... highly dependent on local soil, climatic, and ecological characteristics.”

• This occurs, at least in West Africa, at the scale of kilometers

• Dramatic consequences for understanding agricultural production functions, profitability of new technologies, even social organization,
Moreover, ‘space’ is correlated with other things that matter:
So there is something typically ‘unobserved’ that is correlated with things you care about. Spatial effects exist and matter.
\[ \pi_i(Z_{pi}, w_i, \rho_i) = \max_{x_{pi}} E \rho_i f(x_{pi}. Z_{pi}, \omega_{pi}) + \varepsilon_{pi} - w_i x_{pi} \]

where

\( x_{pi} \) - vector of all the inputs, \( w \) is prices;

\( Z_{pi} \)—observable characteristics of \( p \) and \( i \) (human capital? land characteristics?),

\( \omega_{pi} \) shocks known by \( i \) before production choices are made

\( f(.) \) (scalar) production function, \( \rho \) price of output

\( E \) taken over distribution of \( \varepsilon \).
First-order approximation:

$$\pi_{pi} = Z_{pi}\beta + \gamma G_{pi} + \lambda_i + \lambda_N(pi) + \varepsilon_{pi}$$

NOTE: Two different fixed effects. This is a simple version, more generally
$$\lambda_N(pi)$$ is a smooth function of space.

Estimator:

$$\pi_{pi} - \frac{1}{N_{pi}} \sum_{q \in N_p} \pi_q = (Z_{pi} - \frac{1}{N_{pi}} \sum_{q \in N_{pi}} Z_q)\beta + \gamma(G_{pi} - \frac{1}{N_{pi}} \sum_{q \in N_{pi}} G_q)$$

$$\lambda_i - \frac{1}{N_{pi}} \sum_{j \in N_{pi}} \lambda_j + \varepsilon_{pi} - \frac{1}{N_{pi}} \sum_{q \in N_{pi}} \varepsilon_{qj}.$$

(stata program example available)
### Table 3: Profits and Gender

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**Observations:** 508

**Fixed effects:** household x year, spatial (250 meters) and household x year

Standard errors are consistent for arbitrary heteroskedasticity and spatial correlation.
Profits of a New Technology

\[ \pi_i(w_i, \rho_i, v_i) = \max_{\gamma_i, x_i} E \rho_i f(x_i, \omega_i; \gamma_i) + \varepsilon_i - w_i x_i - v_i \gamma_i \]

Randomize \( v_i \in \{v^L, v^H\}, \ v^H > v^L \)

- Provides \( E(\pi(1) - \pi(0)) \) over \( k_i, \omega_i, \rho, w \)

- obvious that \( E\pi_i(1) > E\pi_i(0) \iff \) yield (1) > yield (2)

- obvious that \( E(\pi_i(1) - \pi_i(0)) > 0 \) does not imply that \( \pi_i(1) - \pi_i(0) > 0 \) for all \( i \).
Selection on $\omega$

suppose $\omega f(x; \Upsilon)$ and $\Upsilon = 1$ increases yield

$$\pi^H(\omega; 1) = \max_{x_i} E \rho f(x_i, \omega; 1) + \varepsilon_i - \omega x_i - \nu^H$$

and

$$\pi^H(\omega; 0), \pi^L(\omega; 1) \text{ and } \pi^H(\omega; 0).$$

$\exists \omega^H$ s.t. for $\omega_i \leq \omega^H$, all $i \in H$ have $\pi^H(\omega_i; 0) > \pi^H(\omega_i; 1)$ and choose $\Upsilon_i = 0$; and $\Upsilon_i = 1$ for all $\omega_i > \omega^H$.

Similarly, there is $\omega^L$ ($< \omega^H$)
The obvious approach to estimating the expected profitability of the new technology is to estimate the regression

\[ \pi_i = \alpha + \beta \Upsilon_i + e_i \]

using \( T_i \) as an instrument for \( \Upsilon_i \).

\[ \hat{\beta} = E \left( [\pi_i(1) - \pi_i(0)] | \omega^L < \omega_i < \omega^H \right) \]

- choosing the level of \( \nu^H, \nu^L \) doesn’t just change the power of the experiment. It changes what you are estimating

- So, for example, increasing the subsidy for adoption (lowering \( \nu^L \)) reduces \( \omega^L \) and thus reduces \( \hat{\beta} \).
Understanding the Production Function

\[ x_i(\rho_i, w_i; \omega_i) = \arg \max_x E \rho_i f(x, \omega_i) + \varepsilon_i - w_i x_i \]

randomize factor prices over individuals, and we can estimate the demand functions and hence \( f \).

(obviously, it’s not really so simple. Even if all else is easy, we need to be concerned about functional form and dimensionality)
Randomization of factor prices to estimate production functions seems such an obvious thing. But we can’t find examples. Why not?

1. Production economists estimate production functions by experimentally varying inputs and observe outputs (Close to Duflo, Kremer and Robinson in their early Busia fertilizer work). Recent examples: Canchi et al. (2010); Tembo et al. (2008)

(a) Like experiment station trials, but we want these on farmers’ plots, integrated into farming systems

(b) Once integrated into farmers’ overall decision-making, we get optimizing behavior, which leads us back to estimating $x()$

2. $x(.)$ depends on farmer knowledge, learning
3. How to induce variation in $w$? With complete markets, it’s not obvious. With a subsidy, just demand an infinite amount and sell the surplus. With a tax, just buy on the market.

(a) Transaction costs provide a window through which small variation in $w$ may be possible, which in turn permits local estimates of $x(.)$ and $f(.)$.

4. Conditioning on $\omega$ is required. This is hard; one possibility is to rely on spatial correlation to take care of most of it.
\( x_i \in \{1, 0\} \)

\( x_i = 1 \) iff \( \omega_i f(1) - w \geq \omega_i f(0) \)

IV: input price \( w_i \). We set \( w_i = w^H \) for randomly-chosen group H, \( w_i = w^L \) for group L. For \( i \in H \),

\[
x_i = 1 \text{ if } \omega_i(f(1) - f(0)) > w^H, 0 \text{ otherwise}
\]

for \( j \in L \),

\[
x_j = 1 \text{ if } \omega_j(f(1) - f(0)) > w^L, 0 \text{ otherwise}.
\]

We observe \( y_i = \omega_i f(x_i) + \varepsilon_i \). Now estimate

\[
y_i = \alpha + \beta x_i + e_i
\]
using \( w_i \) as an instrument for \( x_i \)

\[
\hat{\beta} = E \left( \omega(f(1) - f(0)) \left| \frac{f(1) - f(0)}{w^H} < \omega_i < \frac{f(1) - f(0)}{w^L} \right. \right)
\]

- Standard LATE issues, as in the discussion above