Yield gaps and natural resource use efficiency

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Motivation

• Global demand for meat is projected to increase by 85% from 2005/2007 to 2050 and this demand will have to be met from an increasingly scarce natural resource base.

• So:
  ▫ Do we need to increase natural resource use efficiency?
  ▫ How do we define it?
  ▫ How do we measure it?
Outline

• Conceptual framework for the discussion:
  ▫ Production possibilities
  ▫ Technical change, efficiency and productivity
  ▫ Yields and yield gaps
  ▫ Economic efficiency and allocation efficiency, maximizing profits and minimizing costs

• Implications for the use of natural resource efficiency measures

• Conclusions
Production Possibility Space (PPS): Set of all feasible input combinations that can produce $y$

$X_1 =$ Fertilizer per kg of $y$

$X_2 =$ Land per kg of $y$
Technical Change and the technological frontier

X1=Fertilizer per kg of y

X2=Land per kg of y
Technical efficiency

\[ X_1 = \text{Fertilizer per kg of y} \]

\[ X_2 = \text{Land per kg of y} \]

Efficiency of \( A' \) = \( \frac{OA}{OA'} < 1 \)

Efficiency of \( A \) = \( \frac{OA}{OA} = 1 \)
Efficiency change

\[ dE = \frac{OA}{OA'} \times \frac{OA''}{OA} = \frac{OA''}{OA'} \]
Yields and the yield gap

- $X_1 =$ Fertilizer per kg of y
- $X_2 =$ Land per kg of y

Max. Yield

Average yield

Yield gap
Economic efficiency

\[ X_1 = \text{Fertilizer per kg of } y \]

\[ \text{(Cost of } y/\text{Pf}) \]

Total cost in kgs of fertilizer

\[ \text{Cost of } y = Pf \times X_1 + Pl \times X_2 \]

\[ X_1 = \left(\frac{\text{Cost of } y}{\text{Pf}}\right) - \left(\frac{\text{Pl}}{\text{Pf}}\right) \times X_2 \]

Lower cost
Economic efficiency: change in relative prices

Cost of y = Pf'*X1 + Pl'*X2

\[ X_1 = \frac{\text{Cost of y}}{Pf'} - \frac{Pl' \cdot X_2}{Pf'} \]

Lower land of price wrt fertilizer
Economic efficiency: South Asian prices

X₁=Fertilizer per kg of y

Economic Efficiency of B = OBₑ/OB < 1
Economic efficiency: Brazilian prices

- \( X_1 = \text{Fertilizer per kg of y} \)
- \( X_2 = \text{Land per kg of y} \)

**Economic Efficiency**

\[
\text{Cost}^* = \frac{\text{Brazil's total cost}}{\text{Asia's total cost}} = 1
\]

Economic Efficiency of B = \( OB/OB = 1 \)
Implications

- What are the problems with this definition?
  - Natural resource use efficiency is the “optimum” or “minimum” amount of natural resource inputs used to produce a given quantity of output
Natural resource efficiency and the yield gap

\( X_1 = \text{Fertilizer per kg of } y \)

Max. Yield

\( X_2 = \text{Land per kg of } y \)

Cost*

\( \text{O} \)

\( \text{A'} \)

\( \text{F'} \)

\( \text{I} \)

\( \text{II} \)
Conclusions

• Partial measures of efficiency of natural resource use have similar problems to those of a partial productivity measure like “yield”

• Could be useful as a proxy indicator in particular cases:
  • Select the relevant indicator according to the problem at hand
  • Applied within homogeneous agroecological and economic conditions
Conclusions

• Ideally, total factor efficiency measures should be used
• E.g. the material balance condition (Coelli and others) is a multifactor measure that can be used to analyze a wide variety of situations.