Comparisons of Capital Input in OECD Agriculture, 1973-2011

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Introduction

It is widely observed that agricultural productivity has grown unevenly across countries

• A significant disparity in productivity levels and growth between developed countries (Gollin et al. 2014a, b) and within individual country (Alston et al. 2015).

Recent literature points out differences in relative capital intensities as the proximate cause for this uneven performance

• Embodiment hypothesis: technological innovation is usually embodied in capital

This paper aims to integrate estimates of capital input into the production accounts for agriculture for 17 OECD countries

• To compare relative levels of land and depreciable capital input in agriculture

• To identify capital accumulation as a (conditional) source of convergence
Introduction

In theory, measuring capital input requires construction of capital stocks (Diewert 2008), and it is a challenging task for agriculture because

- Methodology problems remain
- Data constraints are more binding

Based on data source used, studies comparing agricultural capital input between countries are categorised into two groups

- FAO data for both developed and developing countries: Crego et al. (1998), Larson et al. (2000) and Butzer et al. (2010)

Each of these studies have their merits and weaknesses

- Covering limited countries and time period
- Focusing mainly on depreciable assets
International comparison-FAO data

Source: Fuglie and Rada (2014).
Introduction

This paper distinguishes between land and depreciable assets

• Estimating the capital stock for each asset type with the age-efficiency model

• Deriving capital service flows from capital stocks by means of capital rental prices

• Adjusting for purchasing power parity (PPP) for cross-country comparison

Contribution to literature: a complete measure of capital input for

• the EU countries, Australia, Canada and the United States over the period of 1973-2011

• accounting for spatial differences in land characteristics (or quality control)
Methodology: Capital Stock

Capital stock of depreciable assets are estimated by using the perpetual inventory method (PIM)

- Estimates of depreciable capital are derived by representing capital stock at each point in time as a weighted sum of past investments
  \[ K_t = \sum_{\tau=0}^{\infty} d_{\tau} I_{t-\tau}. \]

- The weights correspond to the relative efficiencies of capital goods of different ages, so that the weighted components of capital stock have the same efficiency
  \[ d_{\tau} = \frac{(L - \tau)}{(L - \beta \tau)}, 0 \leq \tau \leq L \]
  \[ d_{\tau} = 0, \tau \geq L. \]

where the efficiency function takes the form of a rectangular hyperbola providing a general model for several types of depreciation.
Methodology: Capital Stock

The stock of land is constructed as the ratio of the value of land in agriculture to the corresponding price index.

- Land price is defined as the average value per hectare.
- Data on land are collected for 3,582 regions across the seventeen countries.
- Observations on land in each country are differentiated by region and by land type.
Methodology: Rental Prices

Rental price of capital is based on the correspondence between the purchasing price of each asset and the discounted value of future service flows derived from that asset (Jorgenson 1963, 1973)

- For depreciable assets: assume that firms buy and sell assets so as to maximize the present value of the firm

\[
p \frac{\partial y}{\partial K} = r w_k + r \sum_{i=1}^{\infty} w_k \frac{\partial R_i}{\partial K} (1 + r)^i = c. \quad \implies c = \frac{r w_k}{(1 - F)}
\]

- For land: there is no depreciation such that F=0

The real rate of return is assumed to be ex ante

- It is defined as the nominal yield on government bonds, less the rate of inflation as measured by the implicit deflator for gross domestic product

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Methodology: Purchasing Power Parity

Comparison of relative levels of capital input across countries require relative prices of capital input.

For depreciable assets: PPP reflect the relative prices of the components of capital input in each country.

- An implicit assumption is that the relative efficiency of new capital goods is the same in each country.
- We use investment good prices, taking into account the flow of capital service per unit of capital stock.

Estimating PPP for land input employs a hedonic price function.

- A complete list of land attributes, along with definitions from Sanchez et al. (2003).
Data Source

Capital input in agriculture comprises land and depreciable assets

- Depreciable assets include non-dwelling buildings and structures, plant and machinery, and transportation vehicles

Investment data sourced from individual countries over a long time series.

- The EU countries: Eurostat (Beutel 1997)
- Australia: the Australian Bureau of Statistics
- Canada: Statistics Canada
- The United States: the US Census of Agriculture and the US Agricultural Resource and Management Survey
Empirical Results

The estimated results for the 17 OECD countries will be summarised in four areas

- Comparison of levels of land attributes
  - different endowment
  - different climate conditions
- Relative prices to the United States of capital inputs
  - US monetary policy and strength of the US dollars drives the change over time
- Relative capital input has been increasing over time for all the countries, in particular, after 2000
- Capital structure: land versus depreciable assets
  - The increased use of depreciable capital leads to capital deepening with respect to land
Figure 1: Levels of land attributes for the United States, Canada, Australia, France, Italy, and Germany.

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Figure 1 levels of land attributes (continued)

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Figure 1 levels of land attributes (continued)
Figure 2: quality adjusted price index for land: relative to the US and in logarithm.
Compare Relative Prices of Capital Input

Relative prices of capital input is expressed in logarithmic form over the period 1973-2011

- A positive difference implies a higher price in the comparison country
- A negative difference implies a higher price in the United States

Drivers underlying relative capital input prices

- Relative capital input prices trended higher during the 1970s due to high rates of inflation and a weakening dollar (Feldstein 1978, 1980)
- The situation changed in the early 1980s when the Federal Reserve Board reduced money supply
- Relative prices increased between the mid 1980s and the 1990s, followed by a decline after 2001
Figure 3: Trends of differences in relative capital input prices (denominated in the US dollars)

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Figure 3 Trends of differences in relative capital input prices (denominated in the US dollars): Continued
Figure 3 Trends of differences in relative capital input prices (denominated in the US dollars): Continued
Compare Relative Capital Input

Most countries increase levels of capital input relative to the United States

• All 17 OECD countries increased absolute levels of capital input in agriculture between 1973 and 1979
• Capital input slowed dramatically in most countries since the 1980s
• Growth in capital input recovered during the 2000s

Explanation on changing relative prices of capital input

• Crude oil crisis in the 1970s
• High/low interest rates, inflation and US monetary policies
• The financial crisis after 2008
Figure 4 Trends of differences in relative capital input
Figure 4 Trends of differences in relative capital input (Continued)
Figure 4 Trends of differences in relative capital input (Continued)
Land versus Depreciable Assets

Over time, capital services obtained from land decreased while those obtained from depreciable assets increased in most countries:

- Land input declined in sixteen of the seventeen countries.
- Depreciable capital input increased in twelve of the seventeen countries.

The different growth in land and depreciable capital inputs over time altered the structure of capital input in OECD countries relative to the US:

- Most EU countries increased the ratio of depreciable capital to land relative to the United States.
- Outside the EU, Canada and Australia initially had lower relative ratios of depreciable capital to land.
Figure 5 Relative ratio of depreciable capital input to land input
Figure 5 Relative ratio of depreciable capital input to land input (Continued)
Figure 5 Relative ratio of depreciable capital input to land input (Continued)
Conclusions

Our objective has been to provide a farm-sector comparison of relative levels of capital input among seventeen OECD countries over the period 1973-2011.

- the age-efficiency model is used to construct capital stocks
- consistent cross-country production accounts are employed
- adjusted for the purchasing power parity between countries

Land and depreciable assets are distinguished

- account for disparity in land quality
Conclusions

Relative prices of capital input fluctuated over time

- trended higher between 1973 and 1979, and fell after that
- attributed to high rates of inflation in the United States and a weakening dollar.
- cross-country/ cross-region/cross-sector comparison.

Most countries gained higher levels of capital input relative to the US.

- gains were mainly obtained after 1980s

Structure of capital input has significantly changed with an increasing ratio of depreciable capital input relative to land input