Special Topics in Business Economics
Introduction to Olley Pakes Method

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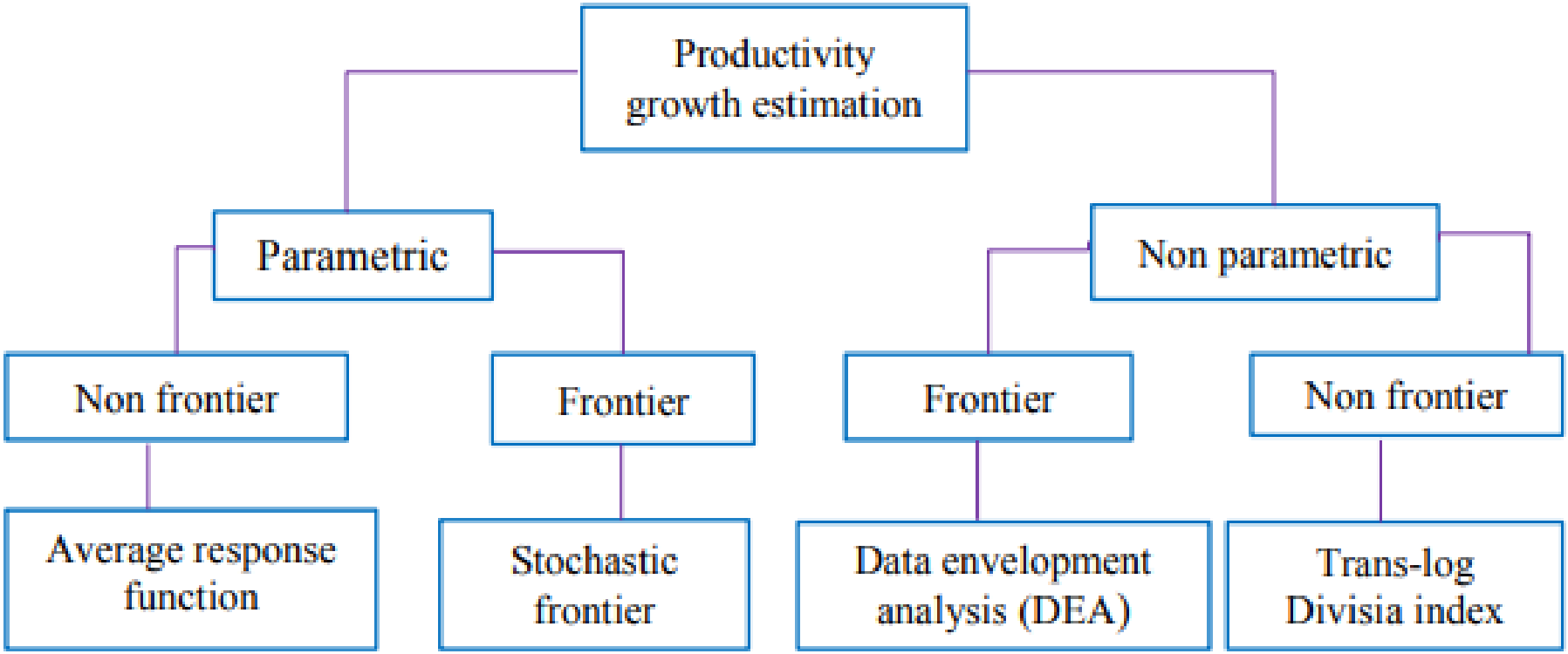
Introduction

- A production function is an equation that expresses the relationship between the quantity of inputs (such as labour and capital) used and the amount of output (product) obtained.
- Productivity is the ratio of what is produced (output) to what is required to produce it (input). Usually this ratio is in the form of an average.
- Productivity indexes
  - TFP, which is the simplest case
  - Malmquist Index measures the productivity changes along with time variations and can be decomposed into changes in efficiency and technology.

Productivity Growth



Source: Mahadevan (2002, pp.6)

Productivity Growth

- **Parametric** and **non-parametric** are the two basic methods for productivity estimations
- The parametric approach often uses the Cobb-Douglas model due to its simplicity
- Non-parametric approach does not need a functional form assumption of the production process
- Non frontier assumes that the unit of analysis are technically efficient
- Frontier steps on the basis of the best performance

Olley-Pakes Method

- Olley and Pakes back in 1996 introduced a semi-parametric method that estimates productivity.
- Productivity is often estimated as the deviation between observed output and output predicted by a CobbDouglas production function estimated by OLS. Such estimates, however, may suffer from simultaneity and selection biases.

Olley-Pakes Method

Simultaneity

Simultaneity arises because productivity is known to the profit-maximizing firms when they choose their input levels. Firms will increase their use of inputs as a result of positive productivity shocks. OLS estimation of production functions will yield biased parameter estimates because it does not account for the unobserved productivity shocks.

Selection bias

Selection bias results from the relationship between productivity shocks and the probability of exit from the market. If a firms profitability is positively related to its capital stock, then a firm with a larger capital stock is more likely to stay in the market despite a low productivity shock than a firm with a smaller capital stock, because the firm with more capital can be expected to produce greater future profits.

Olley-Pakes Method - Assumptions

1. Firm decide at the beginning of each period whether to continue participating in the market or not. If the firm exits, it receives a liquidation value Φ. In case the firm does not exit, it chooses variable inputs (labor, material and energy) and a level of investment, I_{it}.
2. The firm also has state variables: a productivity shock, Ω_{it}; the capital stock, K_{it}; and the age of the firm, a_{it}.
3. Furthermore, expected productivity is a function of current productivity and capital, $E[\Omega_{i,t+1}|\Omega_{it}, K_{it}]$, and that the firms profit is a function of Ω_{it} and K_{it}

Olley-Pakes Method

- Firm i will decide to stay in the market ($\chi_{it} = 1$) or exit the market ($\chi_{it} = 0$) if its productivity is greater than or less than some threshold subject to the firms current capital stock and age, K_{it} and a_{it}. This exit rule is written as follows:

$$\chi_{it} = \begin{cases} 1 \text{ if } \Omega_{it} \geq \Omega_{it}(K_{it}, a_{it}) \\ 0 \text{ if otherwise} \end{cases}$$

- The firm's decision to invest in further capital, I_{it}, depends on Ω_{it}, K_{it}, and a_{it}:

$$I_{it} = I(\omega_{it}, K_{it}, a_{it})$$

Olley-Pakes Method - Production Function

For estimation purposes, we assume Cobb-Douglas Production Function:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + a_{it} + u_{it}$$

$$u_{it} = \Omega_{it} + n_{it}$$

y_{it} is log output for firm i in period t

l_{it}, m_{it}, e_{it} and k_{it} are the log values of labor, material, energy and capital inputs.

a_{it} is the age of the firm

Ω_{it} a productivity shock that is observed by the decision-maker in the firm

n_{it} is an unexpected productivity shock that is unobserved by the decision-maker

Olley-Pakes Method - Overview

- A method for robust estimation of the production function allowing for selection (exit), unobserved permanent differences across firms
- Requires variable (investment in this case) and the unobserved firm-level and also state variable productivity
- Exit is also conditioned on the unobserved productivity

Olley-Pakes - R Commands

olley_pakes(data, formula = y free — capital — proxy — controls, exit = NULL, id = "id", time = "year", bootstrap = TRUE, reps = 2, degree = c(3, 2), verify = TRUE, maxiter = 100, ...)

- *data* A data frame containing the variables of the model
- *exit* An optional formula with the name of the variable indicator of firms last period.
- *id* A character with the name of the indicator variable
- *time* A character with the name of the time variable
- *bootstrap* An optional logical. If TRUE calculate bootstrap standard errors

Olley-Pakes - Stata Commands

opreg *depvar* [if] [in], exit(*varname*) state(*varlist*) proxy(*varname*) free(*varlist*) [cvars(*varlist*) vce(bootstrap, *bootstrap_options*) level(#)]

- exit(*varname*) specifies a dummy variable indicating whether firm *i* exited from the market in year t. A value of 1 indicates the firm exited.
- state(*varlist*) specifies the state variables that appear in the production function. Typical state variables are age and the log of capital.
- proxy(*varname*) specifies the variable that proxies for unobserved productivity. Typically this variable is the log of investment.
- free(*varlist*) specifies the freely variable inputs, such as the logs of materials, energy, and labor.
- cvars(*varlist*) specifies any additional independent variables that will be used in the first and second stages of estimation. Examples include year, size of firm, and region dummy variables.
- vce(bootstrap, *bootstrap_options*) allows specification of options to control the bootstrap process.