Housing New Zealand
Housing New Zealand Corporation

BRANZ

PRODUCTIVITY OF HOUSING CONSTRUCTION

A literature discussion and scoping exercise

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Construction Industry

- Substantive impact on sustaining economic growth.
- Existing studies have mostly relied on *macroeconomic* data (aggregated at the industry-level).
- The evidence suggests stagnant productivity growth.
- Could potentially be attributed to (1) issues of quality adjustment; and (2) failure to differentiate heterogeneous units.
    - ➢ Labour input – master builder *vs* apprentice; working proprietors
    - ➢ Output – stand-alone dwellings *vs* apartment

Construction Industry

- BRANZ funded the study (Jaffe *et al.* 2016) using *microeconomic data* (disaggregated at the firm-level).
- Found contradictory evidence to industry-level analysis.
- Productivity in the construction sector has been *rising* (not deteriorating) since 2001, and the speed of improvement has *outperformed* other comparison sectors

Jaffe, A., Le, T., & Chappell, N. (2016). Productivity distribution and drivers of productivity growth in the construction industry. *BRANZ Study Report SR321*.
Fabling, R., & Maré, D.C. (2015). Production Function Estimation Using New Zealand's Longitudinal Business Database (*SSRN Scholarly Paper No. ID 2660548*). Rochester, NY: Social Science Research Network.

What kind of productivity measures do we need?

To guide the future of Construction

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Are we going to build?

How can we do this better?

Research Questions (Objectives)

1. Where does productivity growth come from?
2. What is the contribution to productivity growth from each different channel?
3. What kind of policy initiative/industrial support would generate the greatest improvement?
4. What makes a ***housing construction*** firm more productive than others?
5. How can we identify the most productive firm(s) amongst others?
6. How can we advise firms to build better?

Housing Construction sector (E3011)

- Housing Construction (E3011) is the largest sub-segment.
- Different *input-output* mixes to consider across sub-segments.
- Different production *technology* to consider across sub-segments.
- The resulting productivity measures will have different implications.
- Nonetheless, the same study can be performed for other sub-segments using different sample(s).

Other-residential Building Construction (E3019)
Non-residential Building Construction (E3020)
Road & Bridge Construction (E3101)
Other Heavy & Civil Engineering Construction (E3109)

Outline

- **Literature Summary**
  - ➢The level of productivity assessment
  - ➢ The input-output measures
  - ➢NZ & International studies
- **Data Scoping**
- **Proposing Empirical Approach**

The level of productivity assessment

Davis, N. (2007). *Construction sector productivity: Scoping report for the department of building and housing.* Wellington: Martin, Jenkins & Associates.

Industry, *Firm*, *Onsite* Productivity

Page, I.C. (2010). Construction Industry productivity. *BRANZ Study Report SR219*.

Industry, *Firm*, *Project* Productivity

Jaffe, A., Le, T., & Chappell, N. (2016). Productivity distribution and drivers of productivity growth in the construction industry. *BRANZ Study Report SR321*.

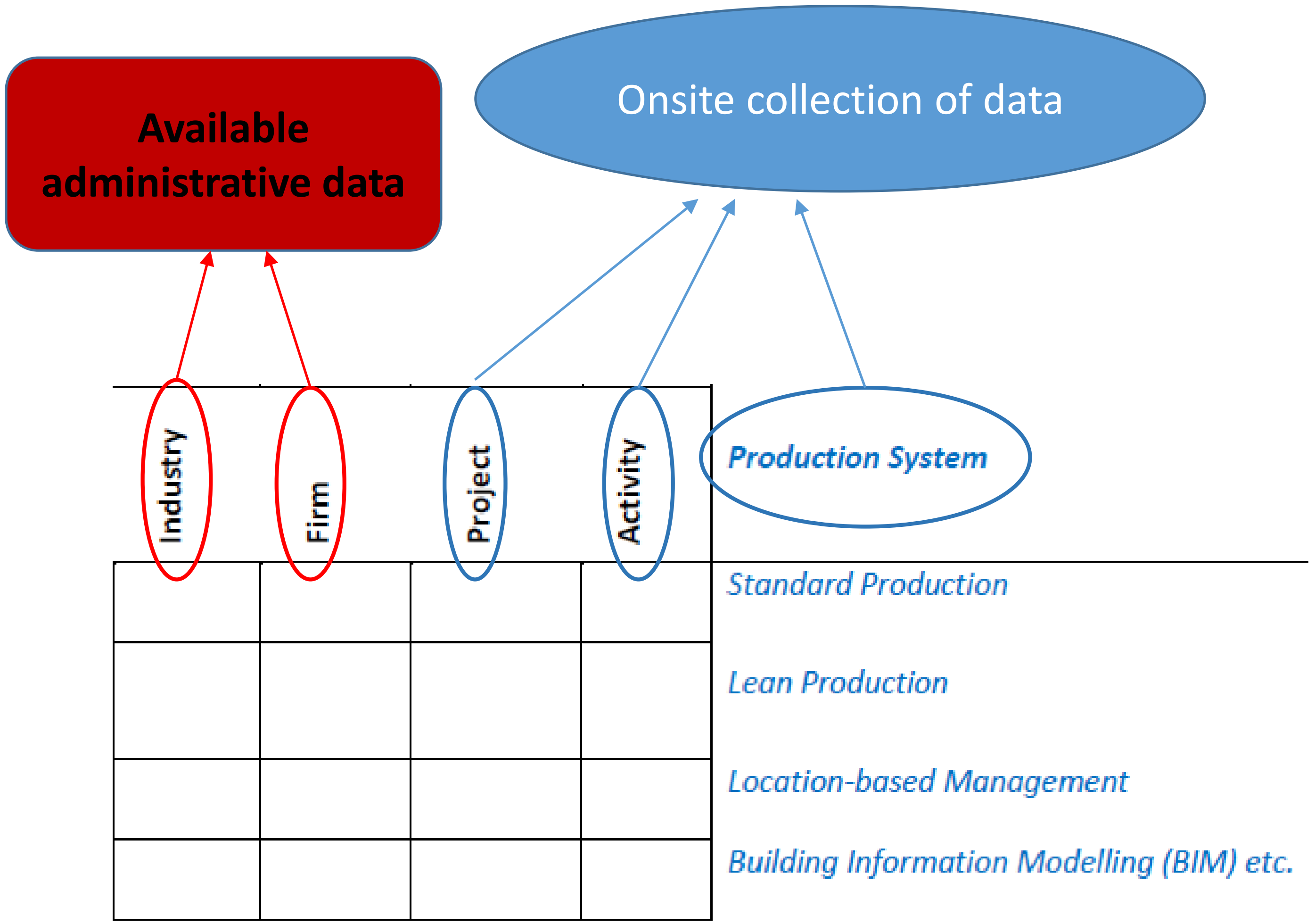
Industry, *Firm*, *Activity* Productivity

Yi, W. & Chan, A.P.C. (2014). Critical review of labour productivity research in construction journals. *Journal of Management in Engineering*, *30*(2), 214-25.

Industry, *Project*, *Activity* Productivity

Kanley, R. (2014). Productivity improvement in the construction process. ***Construction Management and Economics***, *32*(6), 489-494.

The level of productivity assessment



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Industry level Analysis

- *BRANZ Study Reports*
  - Curtis (2018), "Productivity in the construction industry 2017“.
  - Norman, Curtis and Page (2014), "A Construction Dashboard of Key Industry Measures“.
  - Curtis and Norman (2014), "Productivity trends and the implications for our industry“.
  - Page and Norman (2014), "Measuring Construction Industry Productivity and Performance“.
  - Page and Curtis (2011), “Firm productivity variations”.
- *Productivity Commission*
  - Conway and Meehan (2013), “Productivity by the numbers: The New Zealand experience”.
- NZIER (2013), “Construction Productivity: An evidence base for research and policy issues”.
- PwC (2016), "Valuing the role of construction in the NZ economy“.
- Abbott and Carson (2012), “A Review of Productivity Analysis of the New Zealand Construction Industry”, *Australasian Journal of Construction Economics and Building*.
- Trans and Tookey (2011), “Labour Productivity in the New Zealand Construction Industry: A Thorough Investigation”, *Australasian Journal of Construction Economics and Building*.

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Industry level Analysis

- Based on *aggregate macroeconomic data* publically accessible through *Infoshare*. (official statistics)
- Provide *direct comparison* of the construction industry *with the rest of the economy.* (retrospective focus).
- Often perceived to be a *helpful resource* to design strategies and evaluate the state of the sector at the *national level.*
- The practical implications are less obvious.
- A more pragmatic view should focus on *what can be done* within the industry or sub-industry, *to minimize waste* and *maximize outputs and profits.*

Input-Output Measures

Capital

- Capital units index
- Assumes capacity utilization rates remain constant across the economic cycle

Labor

- Labor units index (hours paid)
- Employment count (FTE or headcount)
- No control for skills/experience/education levels (although data is available and it has been investigated separately)
- No control for utilization rates (especially for working proprietor only firms, nearly 75% of the businesses).

Output

- Real GDP (value-added)$ in Construction
- Total value of building consents/residential consents
- Total floor areas of building consents/residential consents

Energy, Material and Services

- KLEMS approach (EU and Australia) is not available in NZ
- Separately identifying energy, materials and services is beneficial

- off-site production of prefabricated buildings or building components are included in *C222 Structural Metal Product Manufacturing*;
- Architectural or building consultancy services are included in *M692 Architectural, Engineering and Technical Services*
- rental and hiring industry (L66)
- timber and pluming goods are included in *F333 for Wholesaling*

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Firm level Analysis

NZ Longitudinal Business Database – survey and tax records

- Fabling and Maré (2015)
- Jaffe, Le and Chappell (2016)
- Jaffe and Chappell (2018)

Spanish SABI database – financial statements

- Kapelko and Abbott (2017)
- Kapelko and Oude Lansink (2015)
- Kapelko, Lansink and Stefanou (2014)
- De Jorge Moreno (2016)

Input-Output Measures

Capital (deflated using the Capital Goods Price Index)

- Depreciation
- rental and leasing costs
- cost of borrowing

Labor

- working proprietors (headcount) – **around 75% of housing construction businesses are WP only**
- employees (FTE, derived from Linked Employer Employee data)

Intermediate Input

- $ total purchase and expenditure (exclude wage & salary payment, depreciation, interests, rental and leasing costs)

Output

- $ gross output sales (include other source of income and stock change)

Data Scoping

Longitudinal Business Database (LBD)

- **Longitudinal Business Frame (LBF)** – *firm demographics*
- **Annual Enterprise Survey (AES)** – *financial performance and financial position*
- **Company Financial Statements Summary (IR10)**
- **Company Income Tax Return (IR4)** - *non-salary payments made to working proprietors*
- **Business Operations Survey (BOS)** - *firms with a rolling mean employment of at least 6*

Integrated Data Infrastructure (IDI)

- **Population data** – *individual demographics, social-economic status, etc*
- **Education and Training data (MOE)** – *qualification and recent training*
- **Employer Monthly Schedule (EMS)** – *income from all sources*
- **Individual Tax Returns (IR3, IR7, IR4S)**

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Avenues for Exploration

Better Output Measures: alternative measures potentially available if we can link the ***Longitudinal Business Database (LBD)*** with the ***Building Consents data***.

Proposed Empirical Approach

Study 1

Productivity Growth of the New Zealand Housing Construction Sector: A Malmquist Index Decomposition

Study 2

Efficiency Analysis for Housing Construction in New Zealand: A Stochastic Frontier Analysis

Productivity Growth Decomposition

Conceptual Framework

$$Productivity = \frac{Output(s)}{Input(s)}$$ **Absolute Concept**

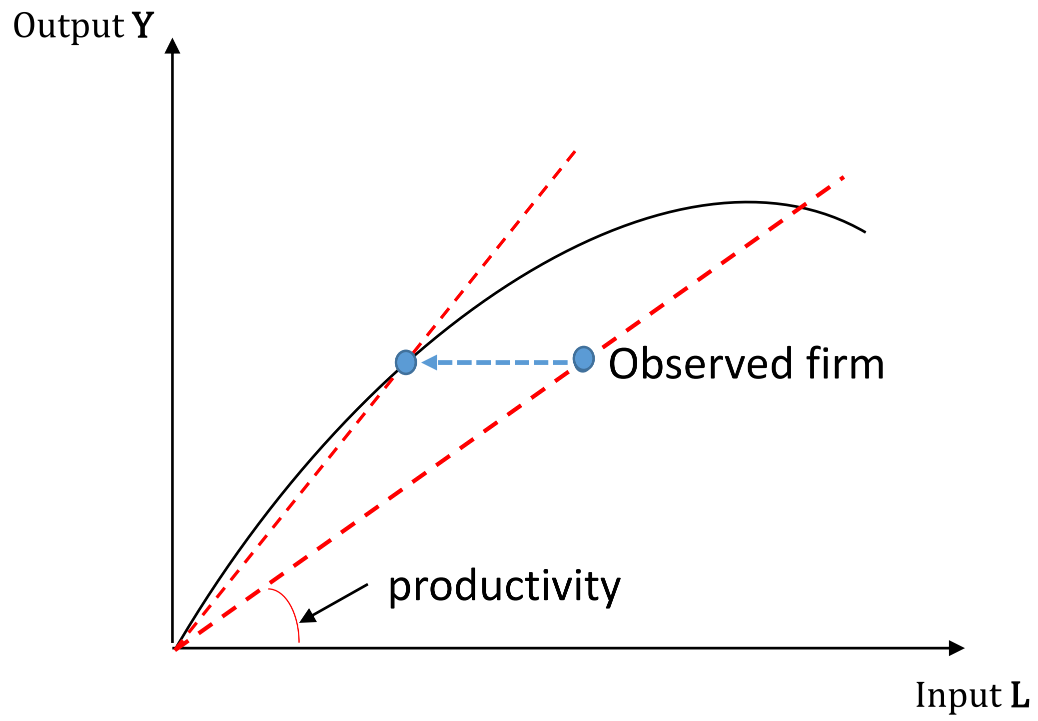
$$\boldsymbol{Efficiency}$$

$$= \frac{actual\ output(s)}{maximum\ output(s)}\ or\ \frac{minimum\ input(s)}{actual\ input(s)}\ for\ technical\ efficiency$$

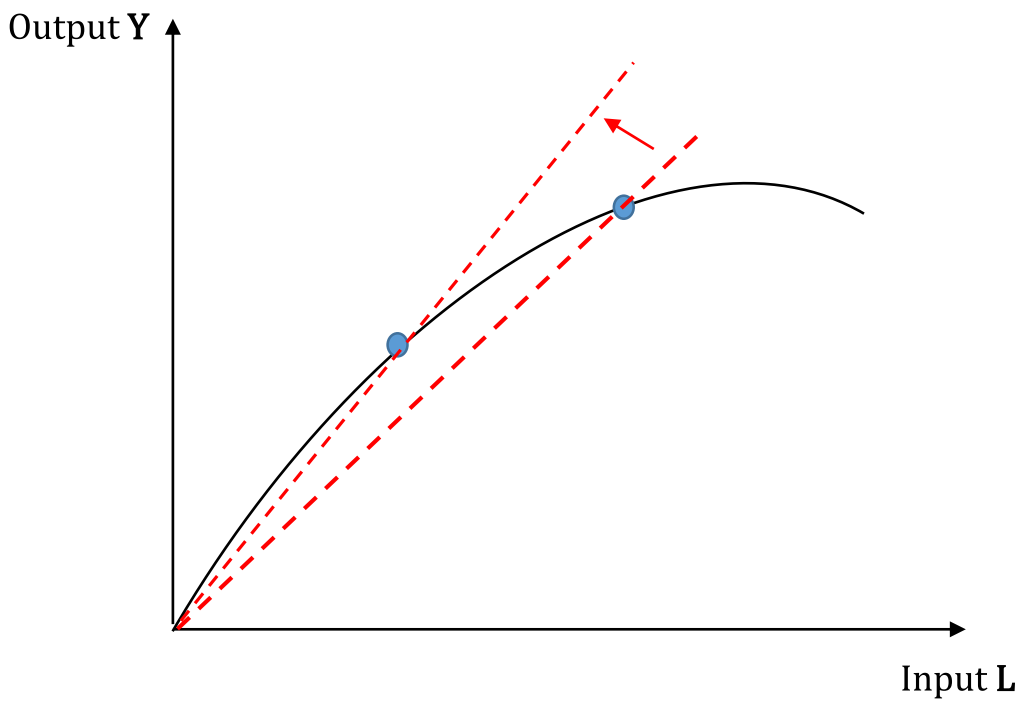
Relative Concept

Productivity Growth Decomposition

↑ Technical efficiency



↑ Scale efficiency



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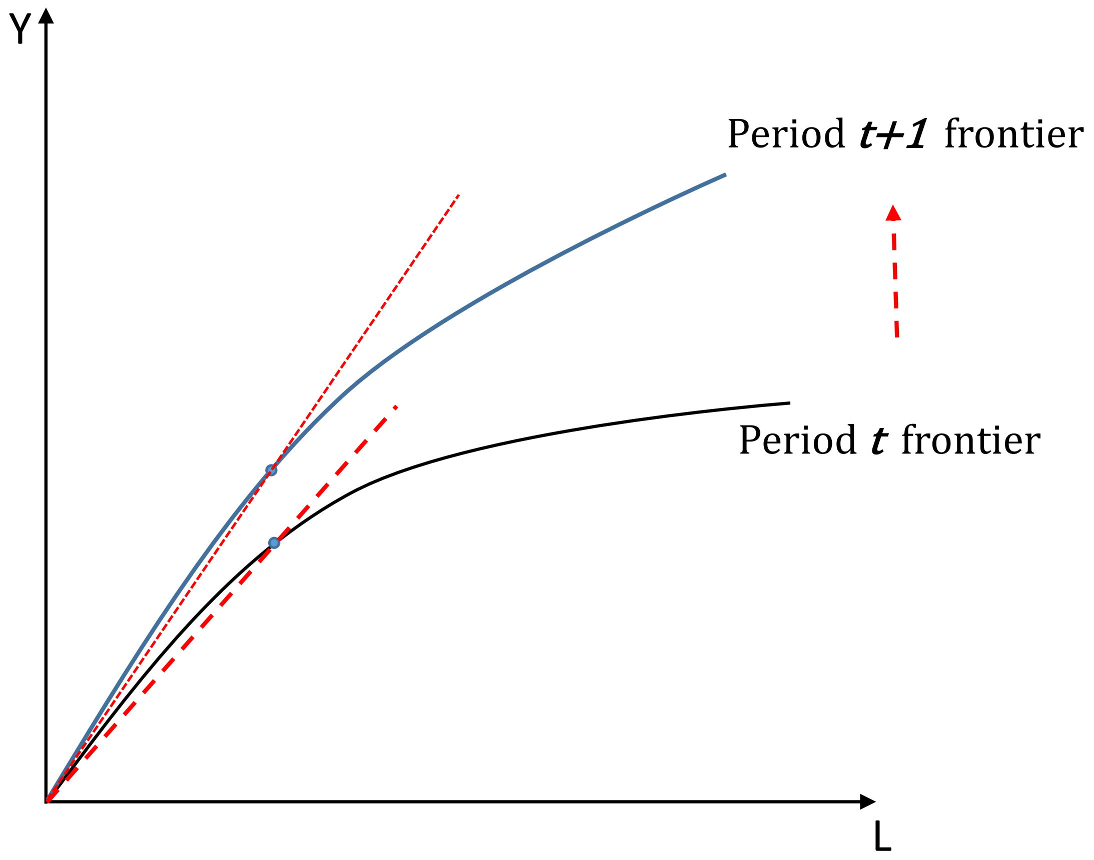
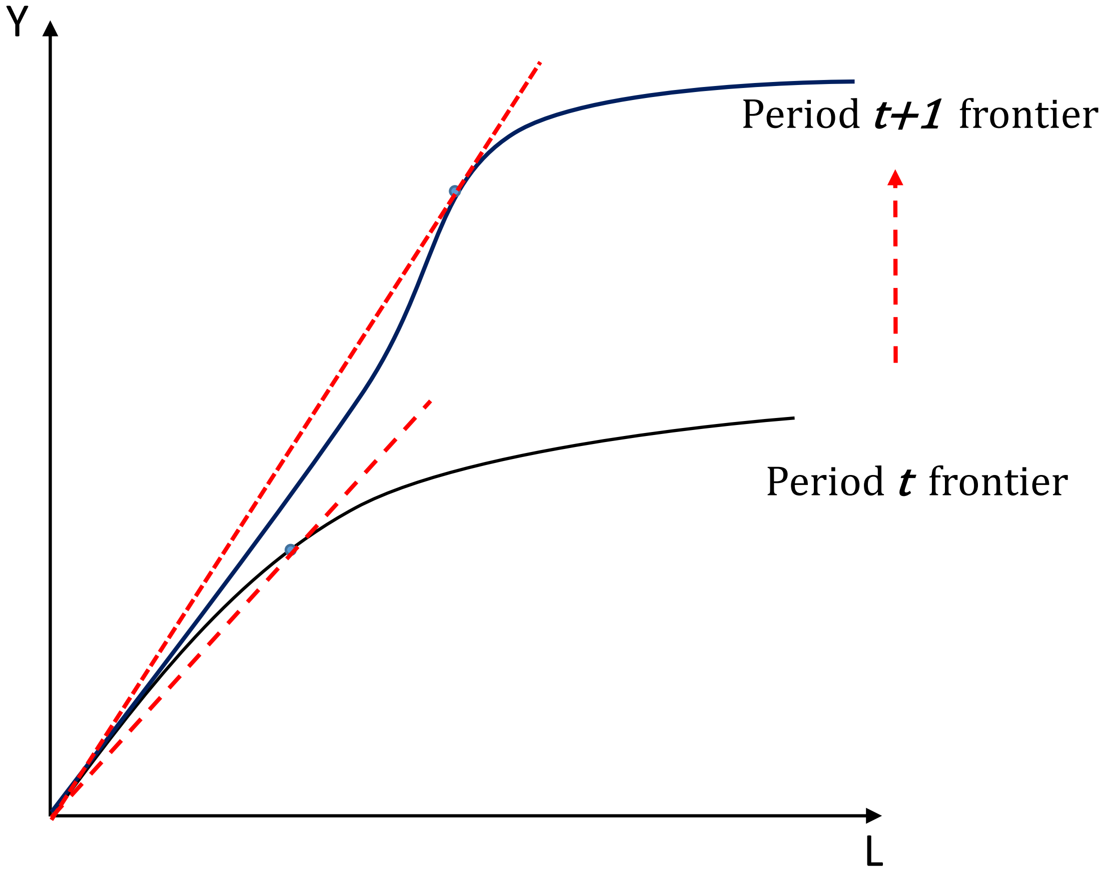
Productivity Growth Decomposition

Technical progress



Scale change of technology



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Policy Motivation

Improve understanding on what would actually work in practice and by how much.

Case: Kapelko and Abbott (2017)

During the period of 2000-2010, the Spanish building construction firms became:

- Less technically efficient (a decline of 20%)
- Further away from the optimal scale (a decrease of 8% in scale efficiency)
- However, there was an average pure technological progress of 16%
- The scale change of the technology also showed an improvement of 6%

Productivity Growth Decomposition

Sources of Productivity Growth

1. Improvements in technical efficiency
2. Improvements in scale efficiency

Directly helping firms to achieve the best practice such as provide entrepreneurial and management training

3. Technical progress
4. Scale change of technology

Creating the *right conditions* and/or *business environment* to encourage innovation and transformation

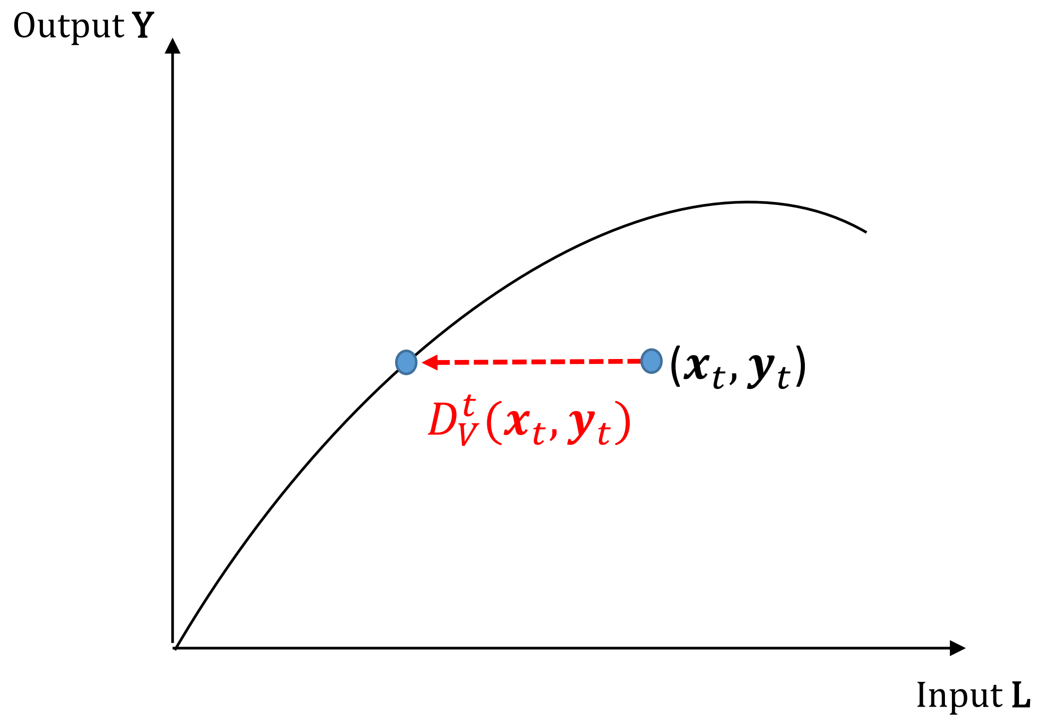
Productivity Growth Decomposition

Malmquist Index Decomposition

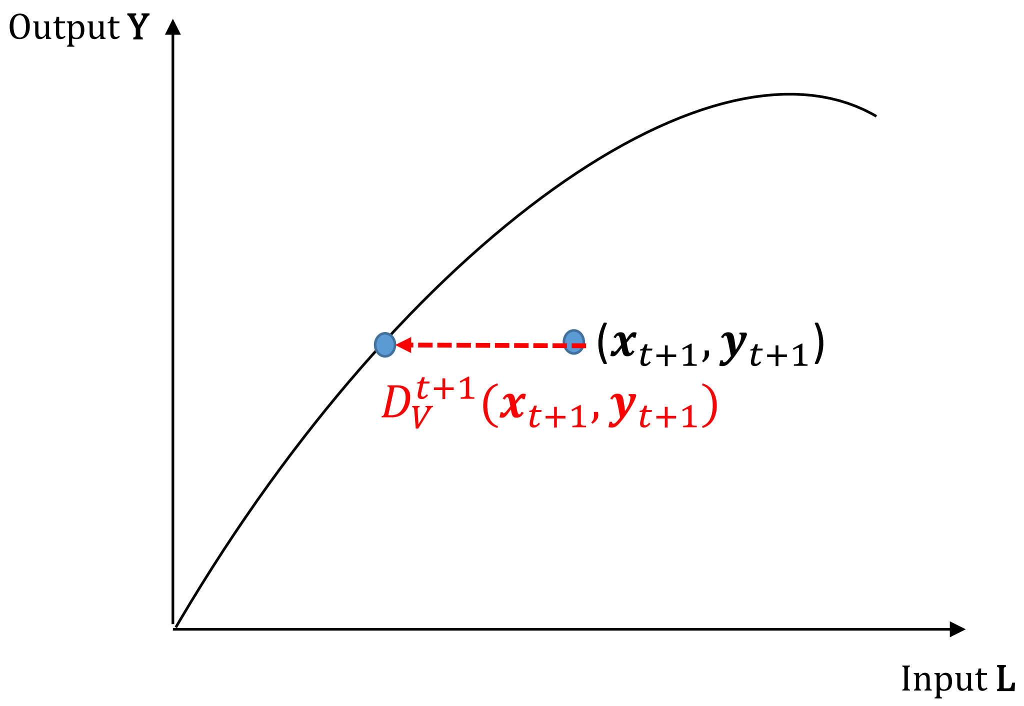
$$M(\boldsymbol{x}^t,\boldsymbol{y}^t,\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1}) = \left[\frac{D_V^{t+1}(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})}{D_V^t(\boldsymbol{x}^t,\boldsymbol{y}^t)}\right] \cdot \left[\frac{D_C^{t+1}(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})/D_V^{t+1}(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})}{D_C^t(\boldsymbol{x}^t,\boldsymbol{y}^t)/D_V^t(\boldsymbol{x}^t,\boldsymbol{y}^t)}\right]$$
$$\cdot \left[\frac{D_V^t(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})}{D_V^{t+1}(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})} \cdot \frac{D_V^t(\boldsymbol{x}^t,\boldsymbol{y}^t)}{D_V^{t+1}(\boldsymbol{x}^t,\boldsymbol{y}^t)}\right]^{1/2}$$
$$\cdot \left[\frac{D_C^t(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})/D_V^t(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})}{D_C^{t+1}(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})/D_V^{t+1}(\boldsymbol{x}^{t+1},\boldsymbol{y}^{t+1})} \cdot \frac{D_C^t(\boldsymbol{x}^t,\boldsymbol{y}^t)/D_V^t(\boldsymbol{x}^t,\boldsymbol{y}^t)}{D_C^{t+1}(\boldsymbol{x}^t,\boldsymbol{y}^t)/D_V^{t+1}(\boldsymbol{x}^t,\boldsymbol{y}^t)}\right]^{1/2}$$

Improvement in technical efficiency

Technical efficiency in period t



Technical efficiency in period $t + 1$



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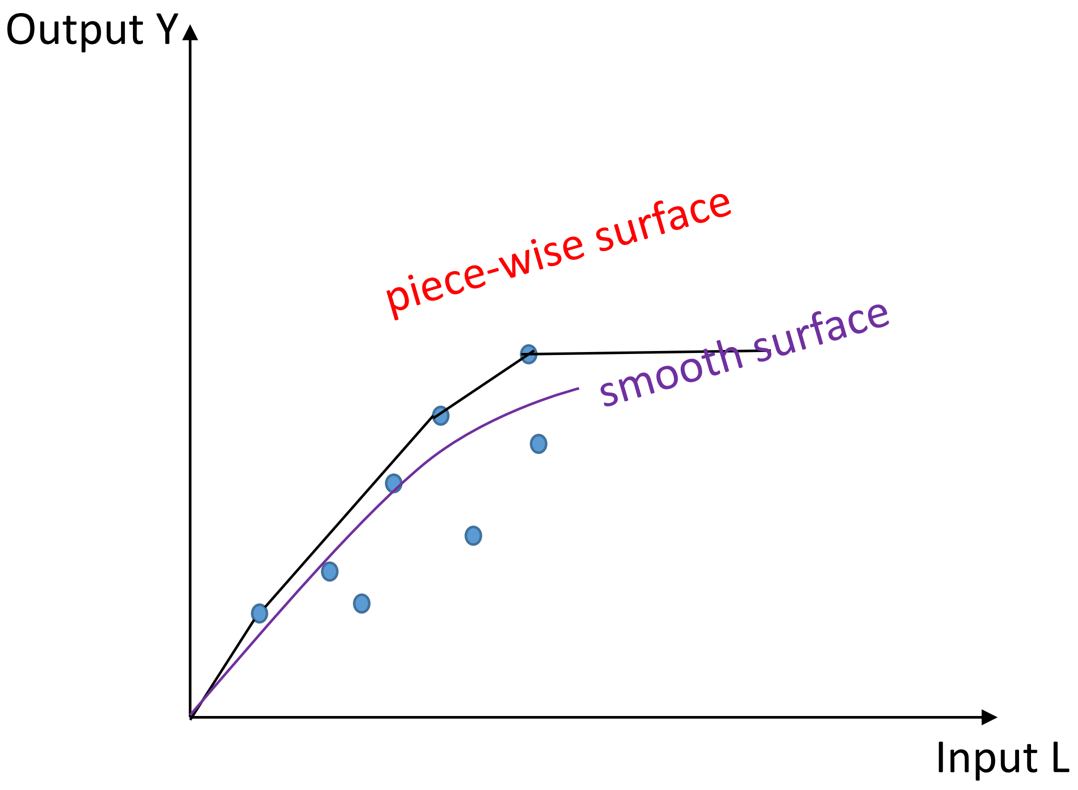
Study 1: Productivity Growth Decomposition

Data Envelopment Analysis (DEA)



- No need to assume a functional form
- No need for distributional assumptions
- A more flexible representation of the production frontier

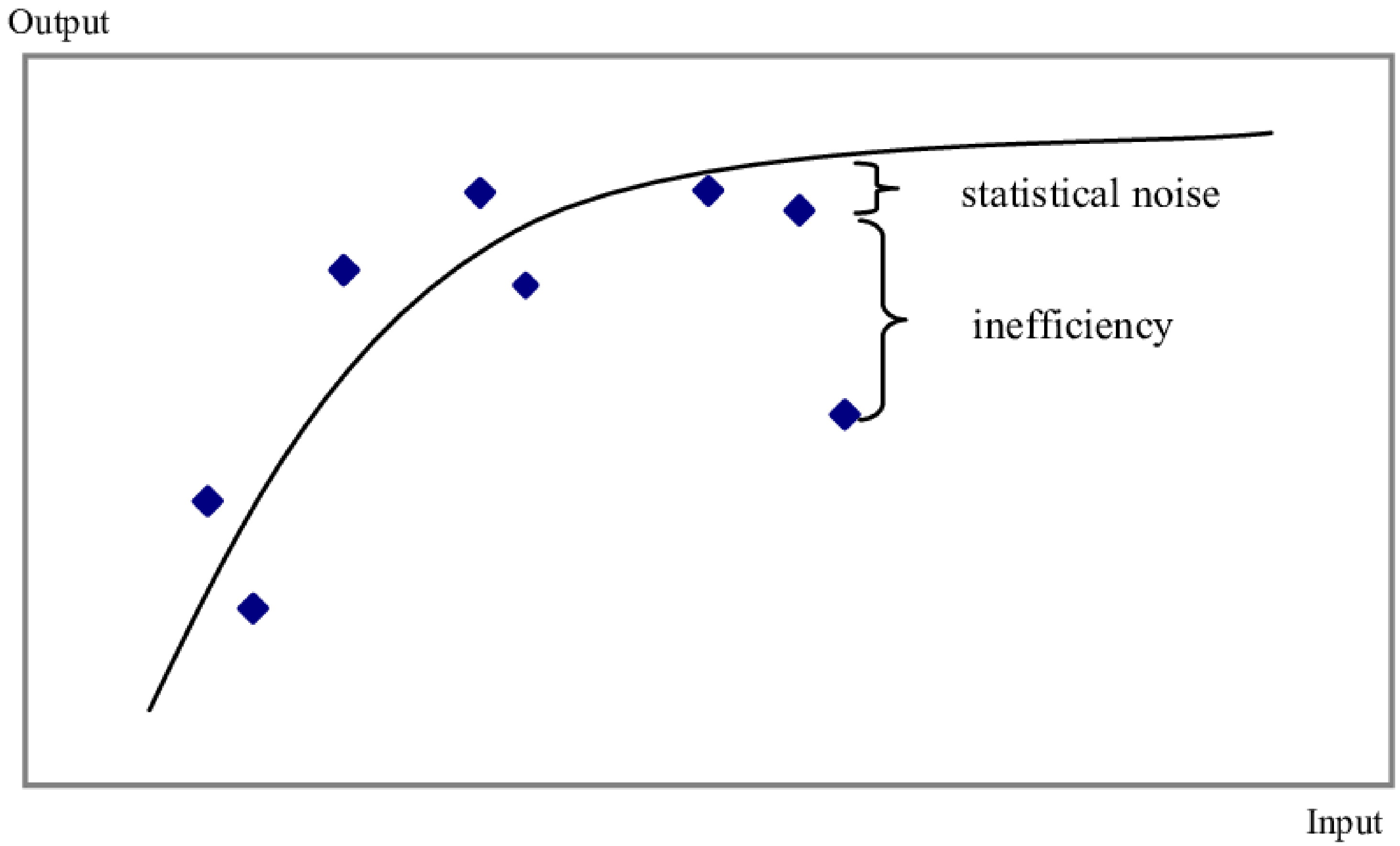
Study 2: Efficiency Analysis with SFA

Stochastic Frontier Analysis

- Develop in-depth understanding of the production technology and market conditions, via the estimation of output elasticities and returns to scale etc.
- Account for noise in the data or random effects in the production process

Efficiency Analysis with SFA

Stochastic Frontier Analysis



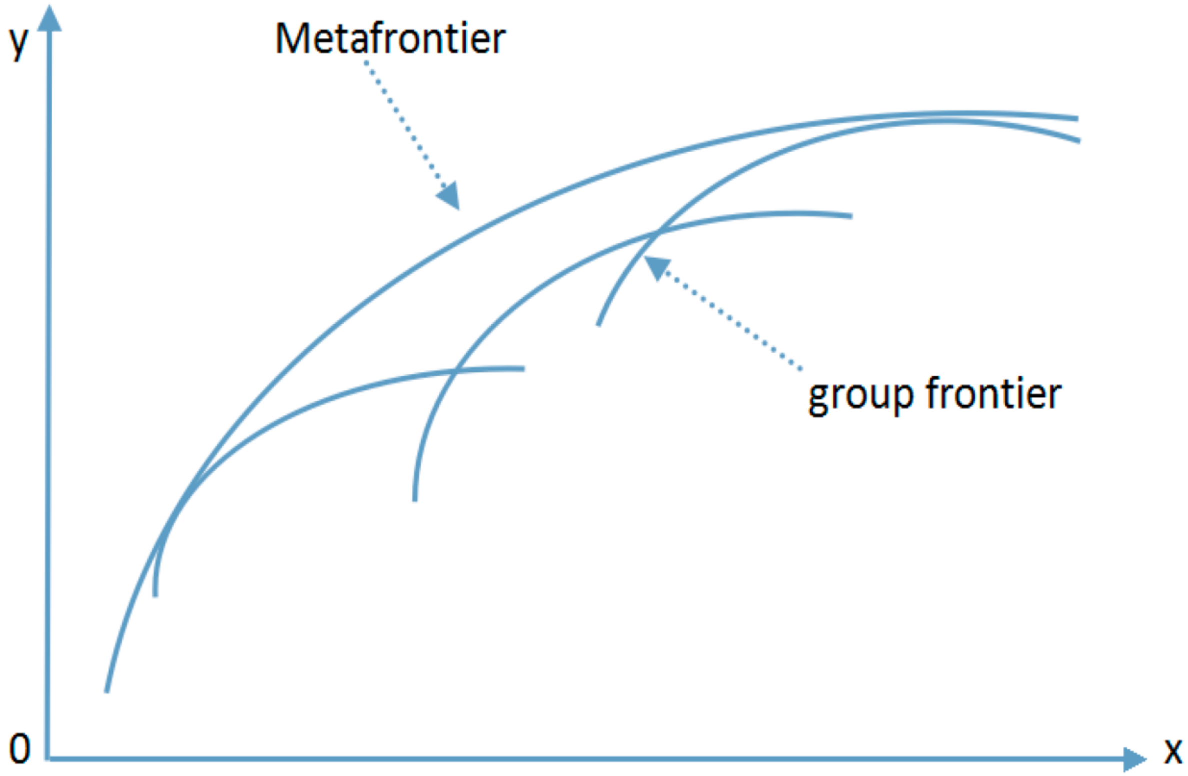
Efficiency Analysis with SFA

Robustness test

- Different functional forms (Cobb-Douglas versus Translog)
- Different distributional assumptions (fixed effects versus random effects)
- Different technologies (meta-frontier SFA)
- *Case study of large construction firms (6+ employees) using BOS*

Efficiency Analysis with SFA

meta-frontier SFA



Why is it better than conventional production function analysis?

- Conventional econometric approach (i.e. production function estimated via OLS) does not have the flexibility advantage offered by DEA, nor the ability to account for random noise as provided by SFA.
- Determinants of efficiency are modelled and estimated simultaneously with stochastic production frontier(s) in one step
- Superior to the conventional two-stage procedures
- Unbiased estimates
- Could separate the effects of determinants on optimization (best practice) and the effects on operating close to the optimal (managerial/operational efficiency)

Efficiency Analysis with SFA

Factors

- Firm age, size, location
- Capital , labour composition and financial health indicators
- Working proprietor background, experience, education
- Specific management practices (Business Operations Survey)

END OF PRESENTATION:-

THANK YOU