Primer on Productivity and Efficiency Concepts

Larry Kaufmann
Pacific Economics Group
Toronto, Ontario
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Overview

Presentation today will “look under the hood” at the main empirical concepts PEG will estimate for 4GenIR

These concepts discussed in more detail in April 2011 Concept Report

Main goals of presentation

- Understand each concept better
- Understand how concepts relate to each other
- Stakeholders better prepared to evaluate and comment on PEG’s empirical estimates

Main Empirical Concepts

Three main empirical concepts that need to be estimated

- Industry input price **inflation**

>>> used to inform choice of inflation factor

- Industry total factor **productivity** (TFP) trend

>>> used to inform value of productivity factor

- Distributor-specific total cost **efficiency**

>>> used to inform assignment of stretch factors

Industry Input Price Inflation

Measures of industry input price inflation are developed in TFP studies because:

- OM&A input prices needed to ‘deflate’ OM&A expenditures and develop estimates of OM&A input quantity; and
- Capital input prices needed to develop estimates of capital costs (needed to estimate cost shares of different inputs)

Productivity: What is It?

Productivity is a measure of the transformation of inputs into outputs

"Total" factor productivity measures the transformation of all inputs into comprehensive output; "partial" factor productivity measures the transformation of a subset of inputs into comprehensive output

Productivity can be measured as a level or rate of change

Efficiency: What is It?

Efficiency addresses whether firms are making *optimal choices* in production (and pricing) given available technologies, input prices, and other factors beyond company control

Economists often distinguish between two types of efficiency

- productive
- allocative

Efficiency: What is It? (Con't)

Productive efficiency: producing the maximum potential output given available technologies

- A firm that is using excessive inputs to produce its level of output is not productively efficient i.e. it could be getting more output out of those inputs

- This means the firm's cost of producing its output is above the minimum potential cost, given available technologies

Efficiency: What is It? (Con't)

Allocative efficiency:

Demand-side: whether the firm is pricing its products efficiently

>>> prices are more efficient as they approach marginal cost

Supply-side: whether the firm is using the optimal *mix* of inputs

Some argue that cost of service regulation is allocatively inefficient because it encourages excessive capitalization/'gold plating'

Productivity: How it is Used in Incentive Regulation

There are two main components of indexing formulas in incentive regulation plans

- Inflation factor >>> input price inflation
- Productivity factor >>> factors other than input price inflation that impact the change in unit cost

Unit cost growth (typically) less than input price inflation, so the value of the productivity factor is typically positive

Productivity: How it is Used in Regulation (Con't)

The 'competitive market paradigm' provides the foundation for using ***industry*** input price inflation and TFP trends in formulas used to adjust allowed rates

$$R = P * Y \qquad (1)$$

$$C = W * X \qquad (2)$$

R = industry revenue index
P = industry price index
Y = industry output quantity index
C = industry total cost index
W = industry input price index
X = industry input quantity index

Productivity: How it is Used in Regulation (Con't)

On a rate of change basis

$$\dot{R} = \dot{P} + \dot{Y} \qquad (3)$$

$$\dot{C} = \dot{W} + \dot{X} \qquad (4)$$

If we set prices so that (long run) industry revenue grows at same rate as industry cost

$$\dot{P} + \dot{Y} = \dot{W} + \dot{X} \qquad (5)$$

$$\dot{P} = \dot{W} + \dot{X} - \dot{Y} \qquad (6)$$

$$= \dot{W} - \left(\dot{Y} - \dot{X} \right) \qquad (7)$$

$$= \dot{W} - \mathrm{TFP} \qquad (8)$$

The Relationship between Productivity and Efficiency

There is clearly a relationship between efficiency and productivity, but they are not equivalent concepts

Productivity will reflect efficiency, but also other factors that impact the relationship between inputs and outputs (and, equivalently, unit costs and input prices)

The Relationship Between Productivity and Efficiency (Con't)

Appendix One of the 2011 Concept Paper presents a mathematical decomposition of TFP growth into six different components

- Scale Economy Effect
- Nonmarginal Cost Pricing Effect
- Cost Share Effect
- Z Variable Effect
- Technological Change
- Inefficiency Effect

The Relationship Between Productivity and Efficiency (Con't)

Two of these terms reflect sources of efficiency gains *i.e.* the extent to which a firm optimizes its choices:

- Cost Share Effect >>> supply-side allocative efficiency
- Inefficiency Effect >>> productive efficiency

Arguably, the non-marginal cost pricing effect is also a source of efficiency gains, but this is far less true for electricity distributors since their pricing/rate design choices are constrained by regulatory and public policy objectives

The Relationship Between Productivity and Efficiency (Con't)

The other four components will be reflected in measured TFP growth but should not be attributed to 'efficiency' change because they largely or entirely reflect factors beyond a distributor's control, rather than its own choices

- Scale Economy Effect
- Nonmarginal Cost Pricing Effect
- Z Variable Effect
- Technological Change

Conclusion

Efficiency studies (used to inform assignment of stretch factors) need to control for business condition variables to make more precise inferences on *company* behavior

Estimates of total factor **productivity** growth capture broader relationship between changes in industry output and input quantities

Appendix: Formal Decomposition of TFP Growth

$$\dot{TFP} = \dot{Y} - (\dot{C} - \dot{W})$$

$$= \underbrace{\left(1 - \sum \varepsilon_{Y_i}\right) \cdot \dot{Y}_i}_{\text{Scale Economy Effect}} + \underbrace{\left(\dot{Y} - \dot{Y}^{\varepsilon}\right)}_{\text{Nonmarginal Cost Pricing Effect}} - \underbrace{\left(\dot{W}^{*} - \dot{W}\right)}_{\text{Cost Share Effect}} - \underbrace{\sum_{n} \varepsilon_{z_n} \cdot \dot{Z}_n}_{\text{Z-variable Effect}} - \underbrace{\dot{g}}_{\text{Technological Change}} - \underbrace{\dot{\eta}}_{\text{Inefficiency Effect}}$$

Appendix: Formal Decomposition of TFP Growth (Con't)

$\dot{Y}_i$ Growth in output *i*

$\dot{Y}^{\varepsilon}$ Growth in cost elasticity-weighted output index

W^* Optimal input price index

$\dot{W}$ Actual growth in input prices

$\dot{Z}_n$ Growth in Z variable *n*

$\dot{g}$ Rate of Technological Change in industry

$\dot{\eta}$ Change in cost inefficiency