

# Comments on BLS-Census Micro-Productivity Project

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December 12, 2014

# Calculating Multi-Factor Productivity Using Micro Data

- One of the most important variables to help understand firm and industry performance
- Does micro data give a similar picture of industry/aggregate productivity movements
- A robust, consistently-defined measure available to RDC users would be widely used
- Stepping stone to moving beyond manufacturing to large sectors of the economy
- Excellent project that uses the expertise of BLS and Census

# Growth Accounting and Index Numbers

- Developed for aggregate time-series comparisons and Tornqvist index is the basis for BLS program

$$\Delta MFP_t = (\ln Q_t - \ln Q_{t-1}) - \sum_i \frac{1}{2} (S_{it} + S_{it-1}) (\ln X_{it} - \ln X_{it-1})$$

In practice it captures numerous factors: shifts in production function, movements across short-run equilibria, returns to scale. Allows flexible technology and does not impose Hick's neutral technical change

- Issues when moving to micro data:

$$MFP_{ft} = \ln Q_{ft} - \sum_i S_{ift} \ln X_{ift}$$

- What is the reference point? Without reference point it depends on units of measure
- How are factor shares treated? If constant for all firms it imposes Cobb-Douglas form, Hicks neutral technology differences
- How to deal with entry and exit?

# Production Function Estimation (Olley-Pakes)

Production Function:

$$\ln Q_{ft} = \beta_0 + \sum_i \beta_i \ln X_{ift} + \omega_{ft} + \varepsilon_{ft}$$

Two sources of noise: productivity  $\omega_{ft}$  is observed by the firm prior to variable input choice, random shocks to  $\varepsilon_{ft}$  is not. Variable input levels are endogenous and OLS estimates of  $\beta_i$  are biased upward

Productivity Evolution:

$$\omega_{ft} = g(\omega_{ft-1}) + v_{ft}$$

Estimation relies on the presence of an additional variable that is correlated with  $\omega$  that can be used to control for  $\omega$  in production function (investment, materials, labor)

Productivity is (generally) constructed as:

$$\hat{w}_{ft} = \ln Q_{ft} - \hat{\beta}_0 - \sum_i \hat{\beta}_i \ln X_{ift} +$$

# Critique of Production Estimation

- Strengths

- Sensible model of firm choice, observe a serially correlated  $\omega$
- Gives estimates of productivity for each observation - firm/time
- Can separate productivity from returns to scale

- Weaknesses

- Large degree of arbitrariness about control variable.
- Decision depends on (unverifiable) assumptions about timing of variable input choice
- Productivity estimates depend on this assumption
- Cobb-Douglas function implies constant output elasticities/factor shares across observations
- New year of data - reestimate the production function?
- Assumes Hick's neutral technology differences across observations

# Hick's Neutral Technology Assumption

Problematic assumption in cross-section firm data.

How to explain the large variation in  $K/L$  and  $M/L$  ratios for firms of different sizes?

Factor price differences are too small - need enormous elasticities of substitution

Labor saving technology bias is a possible explanation.

Production Models with Biased Technology Differences - utilize information on the variation in input cost shares to estimate non-neutral or factor-augmenting technologies.

Gandhi, Navarro, and Rivers (2009), Doreszelski and Jaumandreu (2014), Zhang (2014).

This further complicates production function estimation.

# Cross-Sectional Variation: Input Levels vs Shares

Across firm variation in input shares is substantial in micro data

	P10	P50	P90	$(P90-P10)/P50$
log L	1.10	2.49	4.25	1.27
Sl	.089	.198	.374	1.44
log M	7.04	8.84	11.23	0.47
Sm	.367	.564	.751	0.68
log K	8.03	9.26	11.42	0.36
Sk	.080	.192	.344	1.37
log Q	7.90	9.57	11.85	0.41

Taiwan electronics industry, 8003 firms in 1991

Cross sectional dispersion in each input's revenue share > dispersion in log input level

# Multilateral Index Numbers

$$MFP_{ft} = (\ln Q_{ft} - \ln Q_t^R) - \sum_i \frac{1}{2} (S_{ift} + S_{it}^R) (\ln X_{ift} - \ln X_{it}^R)$$

$\ln Q_t^R$ ,  $\ln X_{it}^R$ ,  $S_{it}^R$  correspond to a reference point (hypothetical firm) with mean log input/output and mean factor shares.

- Recognizes firm variation in output, inputs, and revenue shares
- Does not assume Hick's neutral differences across firms
- Every firm is compared to reference point, transitive comparisons among firms, unit free
- The firm shares are smoothed by averaging with  $S_{it}^R$
- Reference points can be chain-linked over time, allows time-series comparisons of reference firm
- Additional years do not disturb the historical series
- Can use firm's with one year of data
- Problem with unreasonable shares - trimming necessary



# Other Issues: Imputation and Reporting

- Constructing the reference point in each year
  - Use firms without imputed data, together with sampling weights to construct input, output, share means
  - Compare changes over time with aggregate BLS stats
- Data available in RDCs
  - Can construct  $MFP_{ft}$  for each observation - flags indicating what data is imputed
- Reporting for public use
  - Picture of the Cross-section Distribution of  $MFP_{ft}$  - Percentiles, Robust Measures of Dispersion
  - For industries -revenue share-weighted sum:  $WMFP_t = \sum_f wr_{ft} MFP_{ft}$ ,  
contribution of separate inputs to output

# Conclusions and Recommendations

not the opinion of the Census Bureau, BLS or.....

Very valuable project with many potential uses.

Avoid production function estimation - not appropriate for robust statistical products

Pursue multilateral index numbers - matches well with BLS program

Focus on reconciling reference point in micro data with industry aggregates.

Interpretation of  $MFP_{ft}$  as a measure of resource allocation, not shift in production function, is fine

## ● Theory of Multilateral Index Numbers

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- Good, David H., M. Ishaq Nadiri, and Robin Sickles (1997), "Index Number and Factor Demand Approaches to the Estimation of Productivity," in H. Pesaran and P. Schmidt (eds.), *Handbook of Applied Econometrics, Vol 2: Microeconometrics*. London: Basil Blackwell

## ● Applications to Firm Panel Data

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- Biased Technology with Micro Data
  - Gandhi, A., S. Navarro, and D. Rivers (2009), "Identifying Production Functions Using Restrictions from Economic Theory," University of Wisconsin-Madison, working paper
  - Doraszelski, U. and J. Jaumandreu (2014), "Measuring the Bias of Technological Change," University of Pennsylvania, working paper.
  - Zhang, Hongsong (2014), "Non-Neutral Technology, Firm Heterogeneity, and Labor Demand," The University of Hong Kong, working paper