Misallocation or Mismeasurement?

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Motivation

- Gains from resource reallocation are potentially huge
  - Restuccia and Rogerson (2008)
  - Hsieh and Klenow (2009, 2014)
  - Akcigit, Alp and Peters (2020)

- Has allocative efficiency been rising or falling?
  - Kehrig (2015)
  - Barth, Bryson, Davis and Freeman (2016)
  - Gopinath, Karabarbounis, Kalemli-Ozcan and Villegas-Sanchez (2017)
  - Baqaee and Farhi (2020)

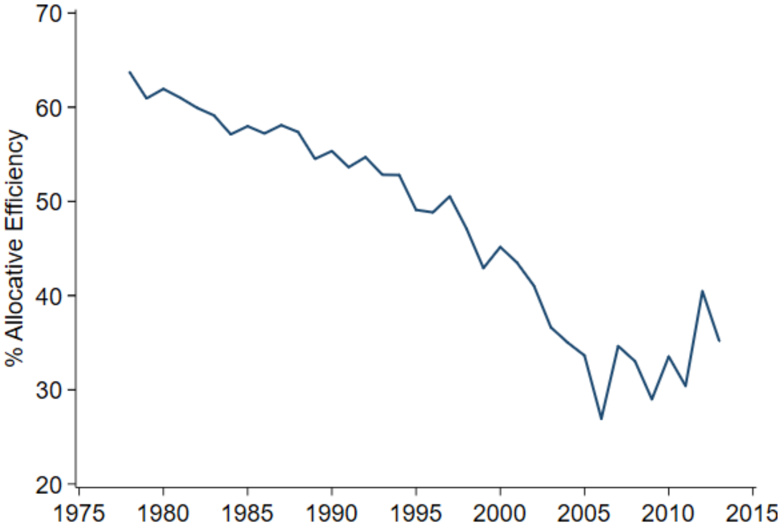
- If falling, it may be a driver of low TFP growth and low real interest rates

U.S. manufacturing in recent decades

- Rising dispersion in *average* products may imply falling allocative efficiency
- For 1978–2013 we find it would translate into:
  - A drag on TFP growth of 1.7 percentage points per year
  - 45 percent cumulatively lower TFP by 2013
- But *measured average* products need not reflect *true marginal* products

  Perhaps mismeasurement and misspecification has worsened instead of misallocation

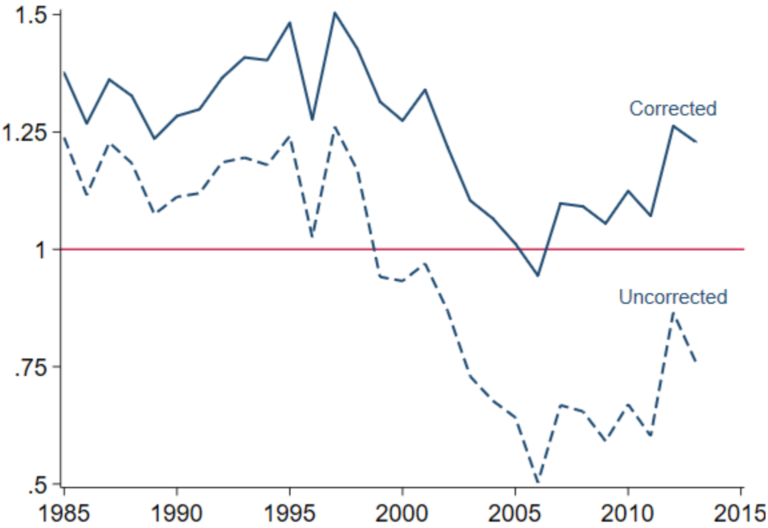
U.S. allocative efficiency



What we do

- Propose a way to estimate misallocation allowing for:
  - Measurement error in revenue and inputs
  - Misspecification due to overhead costs
- Apply to:
  - manufacturing plants in the U.S. 1978–2013
  - manufacturing plants in India 1985–2013
- Preview of results:
  - A less severe decline in U.S. allocative efficiency (0.5% per year, not 1.7% per year)
  - For U.S. (India) potential gains $\sim$ 49% (89%) rather than $\sim$ 123% (111%)

U.S. vs India corrected allocative efficiency



Outline

1. **Illustrative example**
2. Full model
3. TFPR dispersion in U.S. and Indian data
4. Estimating measurement and specification error
5. Corrected measures of misallocation

Simple model setup

- $Y = \left(\sum_i Y_i^{1-\frac{1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}, P = \left(\sum_i P_i^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}$
- $Y_i = A_i \cdot L_i$
- $\max \left(1 - \tau_i^Y\right) P_i Y_i - wL_i$
  - Monopolistic competitor takes w, Y, and P as given
- $\widehat{P_i Y_i} = P_i Y_i + g_i$
- $\widehat{L_i} = L_i + f_i$

Simple model TFPR

- $P_i = \frac{\epsilon}{\epsilon - 1} \cdot \tau \cdot \frac{w}{A_i}$, where $\tau_i \equiv \frac{1}{1 - \tau_i^Y}$

- $\frac{P_i Y_i}{L_i} \propto \tau_i$

- $\text{TFPR}_i \equiv \frac{\widehat{P_i Y_i}}{\widehat{L}_i} \propto \tau_i \cdot \frac{\widehat{P_i Y_i}}{P_i Y_i} \cdot \frac{L_i}{\widehat{L}_i}$

- Let $\Delta X_t \equiv \frac{X_t - X_{t-1}}{X_{t-1}}$ for variable X

Identifying misallocation vs. dispersion in TFPR

- $\Delta \widehat{PY}_i = \Delta \widehat{L}_i \cdot \frac{\tau_i}{\text{TFPR}_i}$
    - assuming distortions and measurement error are fixed over time
    - in which case $\Delta P_i Y_i = \Delta L_i = (\epsilon - 1)\, \Delta A_i$
- We will generalize to allow:
    - Sales R and a composite input I
    - Shocks to distortions and to measurement errors
- We will regress $\Delta \widehat{R}$ on $\Delta \widehat{I}$ in different deciles of TFPR
    - Measurement error should make coefficients fall with TFPR
    - Will use this to estimate $E\left(\ln \tau_i \mid \ln \text{TFPR}_i\right)$

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Full Model (Setup)

- Closed economy, S sectors, N_s firms, L workers, K capital
- $Q = \prod_{s=1}^{S} Q_s^{\theta_s}, \quad Q_s = \left(\sum_i^{N_s} Q_{si}^{1-\frac{1}{\epsilon}} \right)^{\frac{1}{1-\frac{1}{\epsilon}}}$
- $Q_{si} = A_{si}(K_{si}^{\alpha_s} L_{si}^{1-\alpha_s})^{\gamma_s} X_{si}^{1-\gamma_s}$
- $\max R_{si} - (1+\tau_{si}^L)wL_{si} - (1+\tau_{si}^K)rK_{si} - (1+\tau_{si}^X)X_{si}$
  - $R_{si} \equiv P_{si}Q_{si}$
  - Monopolistic competitor takes input prices as given
- $C = Q - X, \quad X = \sum_s^S \sum_i^{N_s} X_{si}$

Model (Aggregate TFP)

- $TFP \equiv \dfrac{C}{L^{1-\widetilde{\alpha}} K^{\widetilde{\alpha}}}$
  - where $\widetilde{\alpha} \equiv \dfrac{\sum_{s=1}^{S} \alpha_s \gamma_s \theta_s}{\sum_{s=1}^{S} \gamma_s \theta_s}$

- $TFP = \overline{T} \times \prod_{s=1}^{S} TFP_s^{\frac{\theta_s}{\sum_{s=1}^{S} \gamma_s \theta_s}}$
  - $TFP_s \equiv \dfrac{Q_s}{(K_s^{\alpha_s} L_s^{1-\alpha_s})^{\gamma_s} X_s^{1-\gamma_s}}$
  - $\overline{T}$ = reflects sectoral distortions (set aside)

Full Model (Sectoral TFP Decomposition)

$$TFP \equiv \frac{Q}{(L^{1-\alpha}K^{\alpha})^{\gamma}X^{1-\gamma}}$$

$$= \underbrace{\left[\frac{1}{N}\sum_{i}^{N}\left(\frac{A_i}{\widetilde{A}}\right)^{\epsilon-1}\left(\frac{\tau_i}{\tau}\right)^{1-\epsilon}\right]^{\frac{1}{\epsilon-1}}}_{AE=\text{Allocative Efficiency}} \times \underbrace{\left[\sum_{i}^{N}(A_i)^{\epsilon-1}\right]^{\frac{1}{\epsilon-1}}}_{\text{Technical Efficiency}}$$

- $\tau_i \equiv \left[\left(1+\tau_i^L\right)^{1-\alpha}\left(1+\tau_i^K\right)^{\alpha}\right]^{\gamma}\left(1+\tau_i^X\right)^{1-\gamma}$

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Indian *Annual Survey of Industries* (ASI)

- Survey of Indian manufacturing plants
  - Long panel 1985–2013
  - Used in Hsieh and Klenow (2009, 2014)
- Sampling frame
  - All plants $>$ 100 or 200 workers (45% of plant-years)
  - Probabilistic if $>$ 10 or 20 workers (55% of plant-years)
  - $\approx$ 43,000 plants per year
- Variables used
  - Gross output (R_i), intermediate inputs (X_i), labor (L_i), wage bill (wL_i), capital (K_i)

U.S. *Longitudinal Research Database* (LRD)

- U.S. Census Bureau data on manufacturing plants
  - Long panel, 1978–2013
  - Used in Hsieh and Klenow (2009, 2014)
- Sampling frame
  - Annual Survey of Manufacturing (ASM) plants
  - $\sim$ 50k plants per year with at least one employee
  - Quinquennial sample for $\sim$ 34k plants, certainty for other $\sim$ 16k
- Variables used
  - Gross output (R_i), intermediate inputs (X_i), labor (L_i), wage bill (wL_i), capital (K_i)

Inferring allocative efficiency as in Hsieh and Klenow (2009)

$$AE = \left[\sum_{i}^{N} \left(\frac{\text{TFPQ}_i}{\text{TFPQ}} \right)^{\epsilon-1} \left(\frac{\text{TFPR}_i}{\text{TFPR}} \right)^{1-\epsilon} \right]^{\frac{1}{\epsilon-1}}$$

- $A_i = \text{TFPQ}_i = \dfrac{(R_i)^{\frac{\epsilon}{\epsilon-1}}}{(K_i^{\alpha} L_i^{1-\alpha})^{\gamma} X_i^{1-\gamma}}$
- $\text{TFPR}_i = \dfrac{R_i}{(K_i^{\alpha} L_i^{1-\alpha})^{\gamma} X_i^{1-\gamma}}$

Inferring aggregate AE

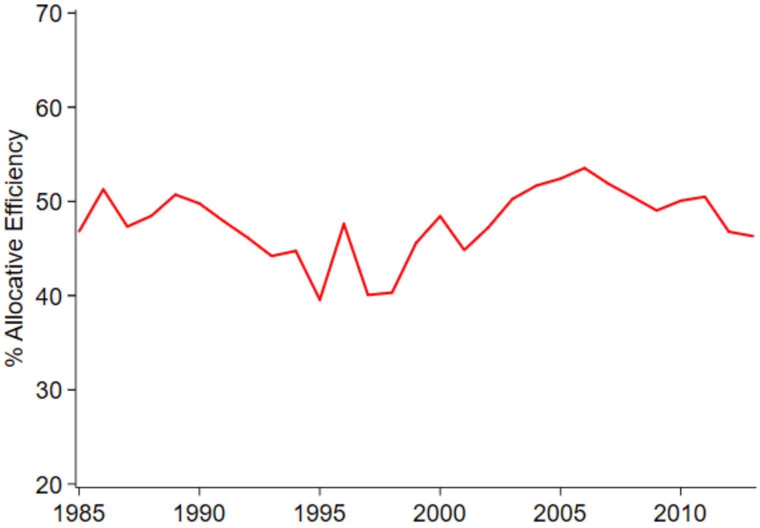
Aggregating within-sector allocative efficiencies:

$$AE_t = \prod_{s=1}^{S} AE_{st}^{\frac{\theta_{st}}{\sum_{s=1}^{S} \gamma_s \theta_{st}}}$$

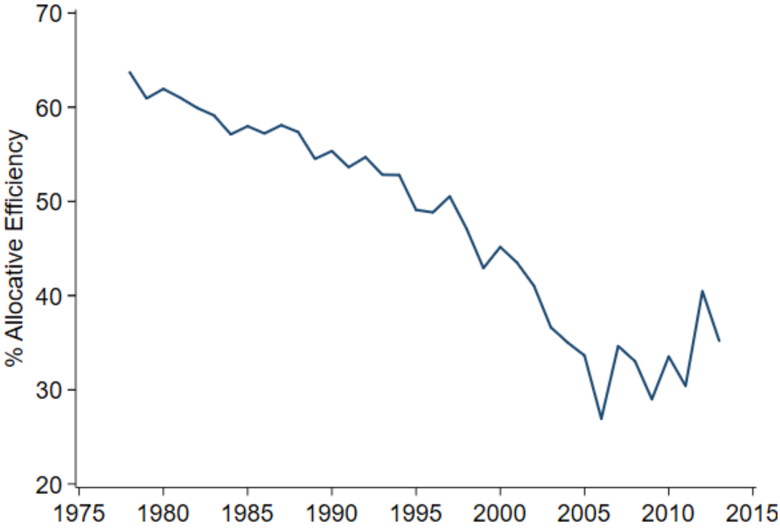
Parameterization:

- $\epsilon = 4$ based on Redding and Weinstein (2016)
- α_s and γ_s inferred from sectoral cost-shares with $r = .2$
- θ_{st} inferred from sectoral shares of aggregate output

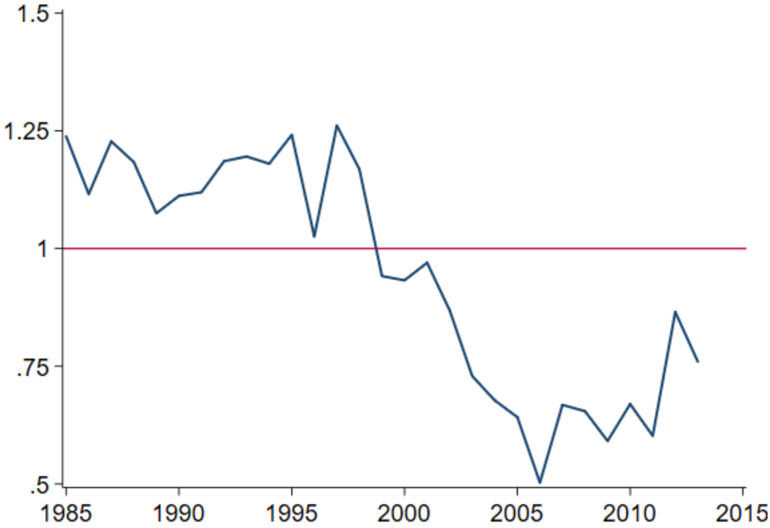
Indian allocative efficiency



U.S. allocative efficiency



Allocative efficiency in the U.S. relative to India



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Previewing our empirical specification

We will regress revenue growth on input growth for a panel of plants:

$$\Delta \widehat{R}_i = \widehat{\lambda}_k + \widehat{\beta}_k \cdot \Delta \widehat{I}_i + e_i$$

- i denotes plant
- k denotes one of 10 deciles of TFPR
- Δ is the growth rate of a variable relative to the sector s mean

Measurement error shows up as lower $\widehat{\beta}_k$ at higher TFPR's

Implementing our TFPR correction

- Regress revenue growth on input growth by decile of TFPR:
  - Divide 25+ year samples into 5 or 6-year windows
  - Unbalanced panel of Indian and U.S. plants
  - $\sim$ 28,000 / 6,000 plants per decile-window in U.S. / India

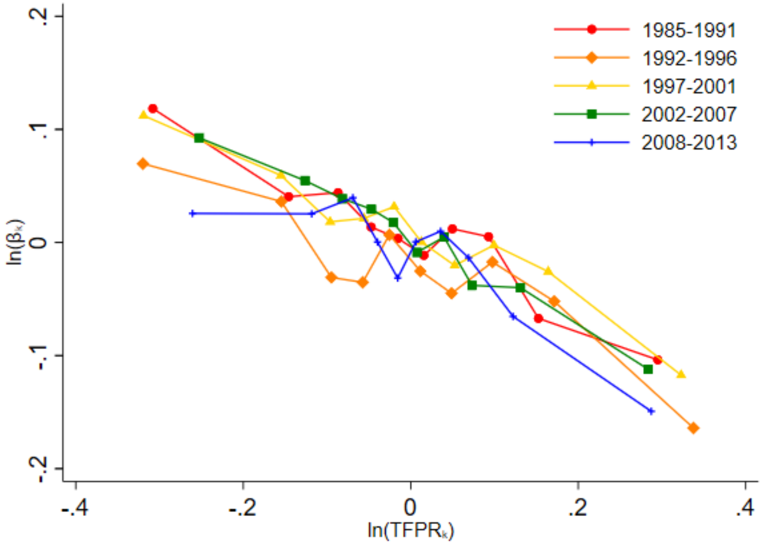
$$\Delta \widehat{R}_i = \lambda_k + \beta_k \cdot \Delta \widehat{I}_i + e_i$$

- i denotes plant, k denotes decile
  - $\Delta \widehat{R}_i$, $\Delta \widehat{I}_i$ and TFPR are deviations from sector-year averages
  - Use Tornqvist average of TFPR for constructing TFPR deciles
  - Observations are weighted by the plant's share of industry costs
  - Trim observations wherein TFPR changes by a factor > 5

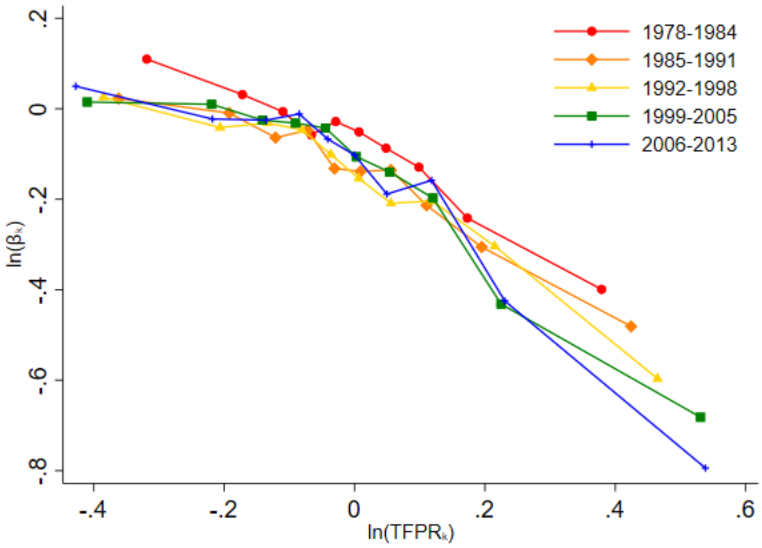
- Merge $\widehat{\beta}_k$ estimates into non-panel sample by decile-window:

$$\ln\left(\widehat{\tau}_i\right) = \ln(\text{TFPR}_i) + \ln(\widehat{\beta}_k) + \varepsilon_i$$

Indian $\widehat{\beta}_k$ slopes wrt TFPR_k



U.S. $\widehat{\beta}_k$ slopes wrt TFPR$_k$



$\widehat{\tau}$ dispersion vs. TFPR dispersion

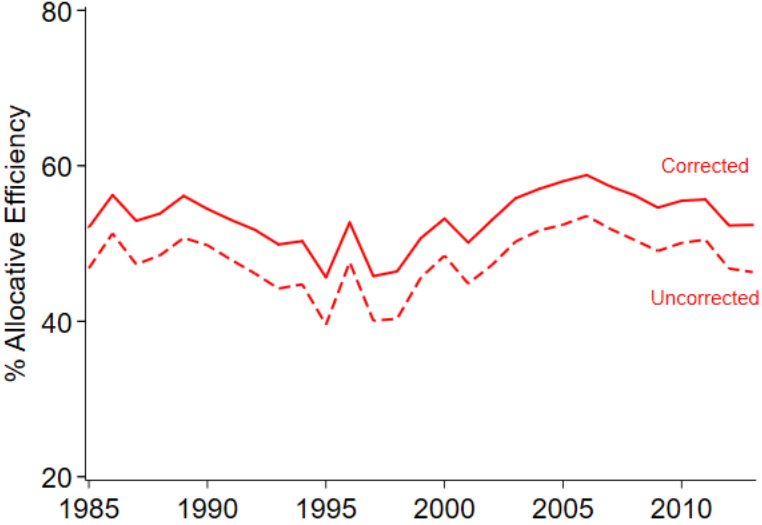
India

	1985–1991	1992–1996	1997–2001	2002–2007	2008–2013
$\sigma^2_{\widehat{\tau}}/\sigma^2_{TFPR}$	**0.68**	**0.76**	**0.74**	**0.69**	**0.71**

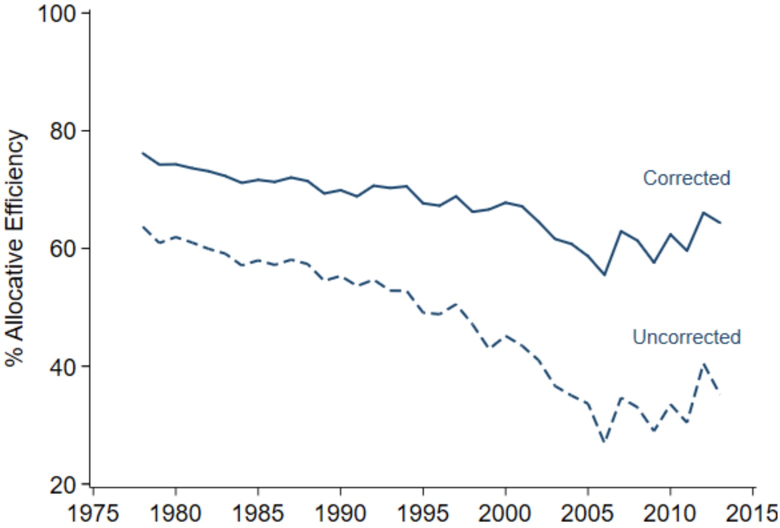
U.S.

	1978–1984	1985–1991	1992–1998	1999–2005	2006–2013
$\sigma^2_{\widehat{\tau}}/\sigma^2_{TFPR}$	**0.40**	**0.43**	**0.38**	**0.32**	**0.28**

Allocative efficiency in India



Allocative efficiency in the U.S.



Uncorrected vs. corrected gains from reallocation

INDIA
1985–2013

	Mean	S.D.
Uncorrected gains	110.9%	17.3%
Corrected gains (estimates)	87.8%	13.8%
Shrinkage	21%	20%

Uncorrected vs. corrected gains from reallocation

U.S.
1978–2013

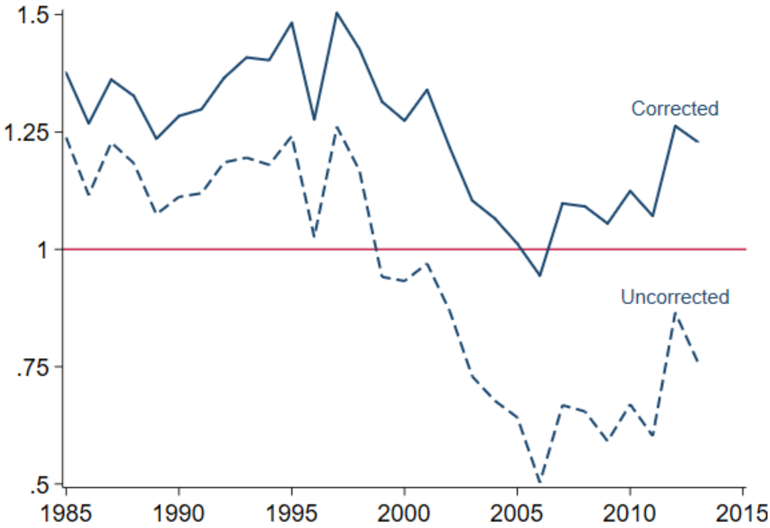
	Mean	S.D.
Uncorrected gains	123.2%	59.7%
Corrected gains (estimates)	49.1%	12.2%
Shrinkage	60%	80%

Cumulative change in AE

	U.S. 1978–2013	INDIA 1985–2013
Uncorrected	-45%	-1.5%
Corrected	-16%	-0.8%

Upshot: **-0.5% per year in the U.S.** (vs. -1.7% uncorrected)

Allocative efficiency: U.S. relative to India



Conclusion

- Proposed a way to estimate true dispersion of marginal products
  - Revenue growth is less sensitive to input growth when averages overstate marginals
  - Requires measurement error be additive and $\perp$ to distortions
- Implemented on Indian ASI
  - Potential gains from reallocation reduced by $\frac{1}{5}$, time-series volatility by $\frac{1}{5}$
- Implemented on U.S. LRD
  - Potential gains from reallocation reduced by $\frac{3}{5}$, time-series volatility by $\frac{4}{5}$
  - **A more modest trend in allocative efficiency (-0.5% per year)**
  - U.S. allocative efficiency is predominantly higher than in India

Should the U.S. Census Bureau have noticed?

Arguably hard to see:

- Variance of $\ln \widehat{R}$ and $\ln \widehat{I}$ rose 7.2% and 7.3% (1978–2013)
- Correlation of $\ln \widehat{R}$ and $\ln \widehat{I}$ fell from 0.993 to 0.979
- 22–58 times higher variance for $\ln \widehat{R}$ and $\ln \widehat{I}$ than for ln TFPR