# World Productivity: 1995-2014

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**With Mehrdad Esfahani and Bart Hobijn**

**(first part draws on work with others)**

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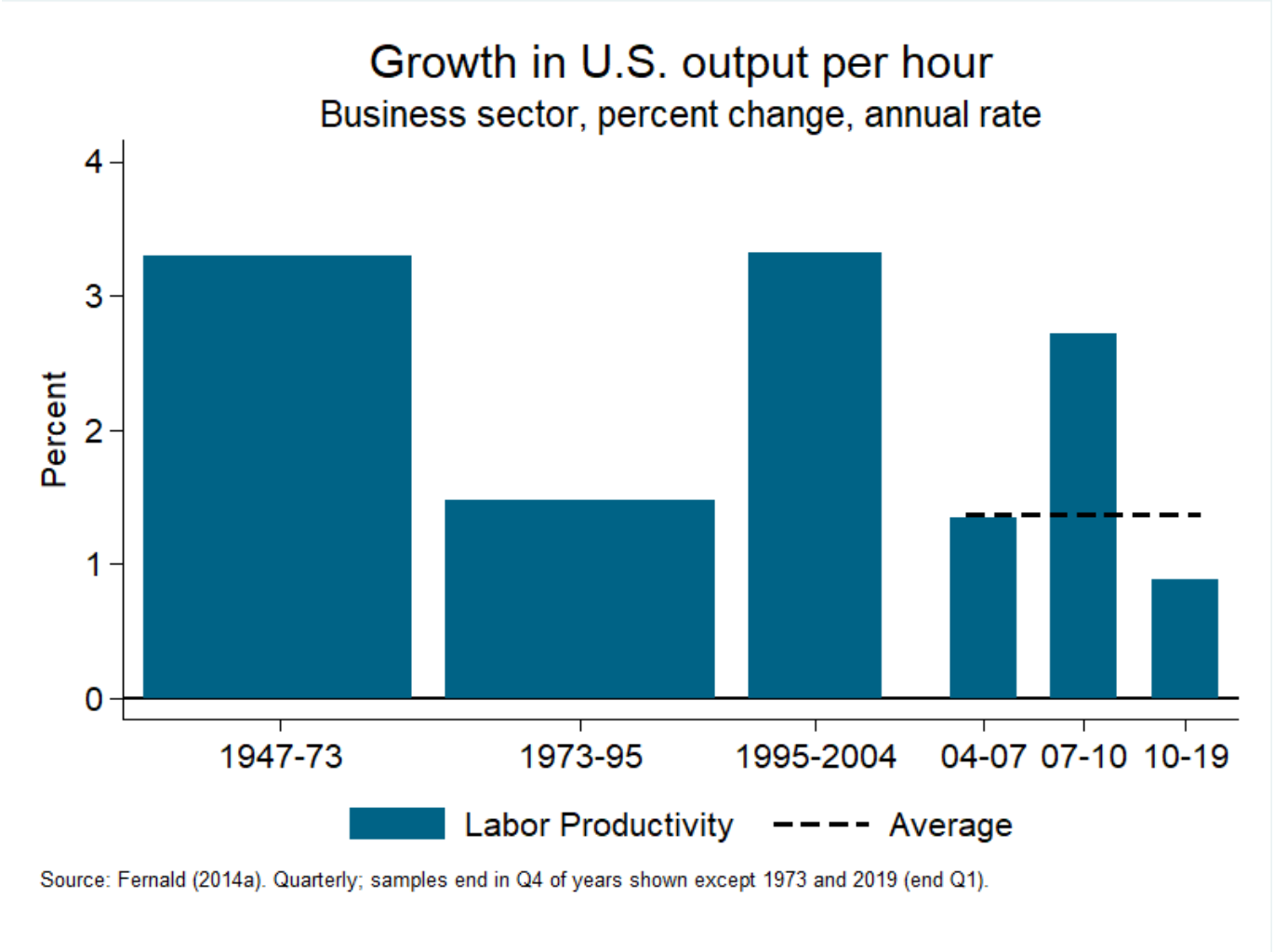
# Big questions

- Why has advanced-economy productivity growth been so modest?
  - Fernald (2014): Slower pace of U.S. IT revolution, not the Great Recession
  - Cette et al (2016): Other advanced economies have been falling behind U.S. since the mid-1990s
- What about the world as a whole?
  - Rise of emerging markets helped sustain global labor productivity growth until 2010
  - Labor growing faster in low-wage locations => a drag on world productivity growth
  - Markups and rising misallocation not reason for slower productivity growth

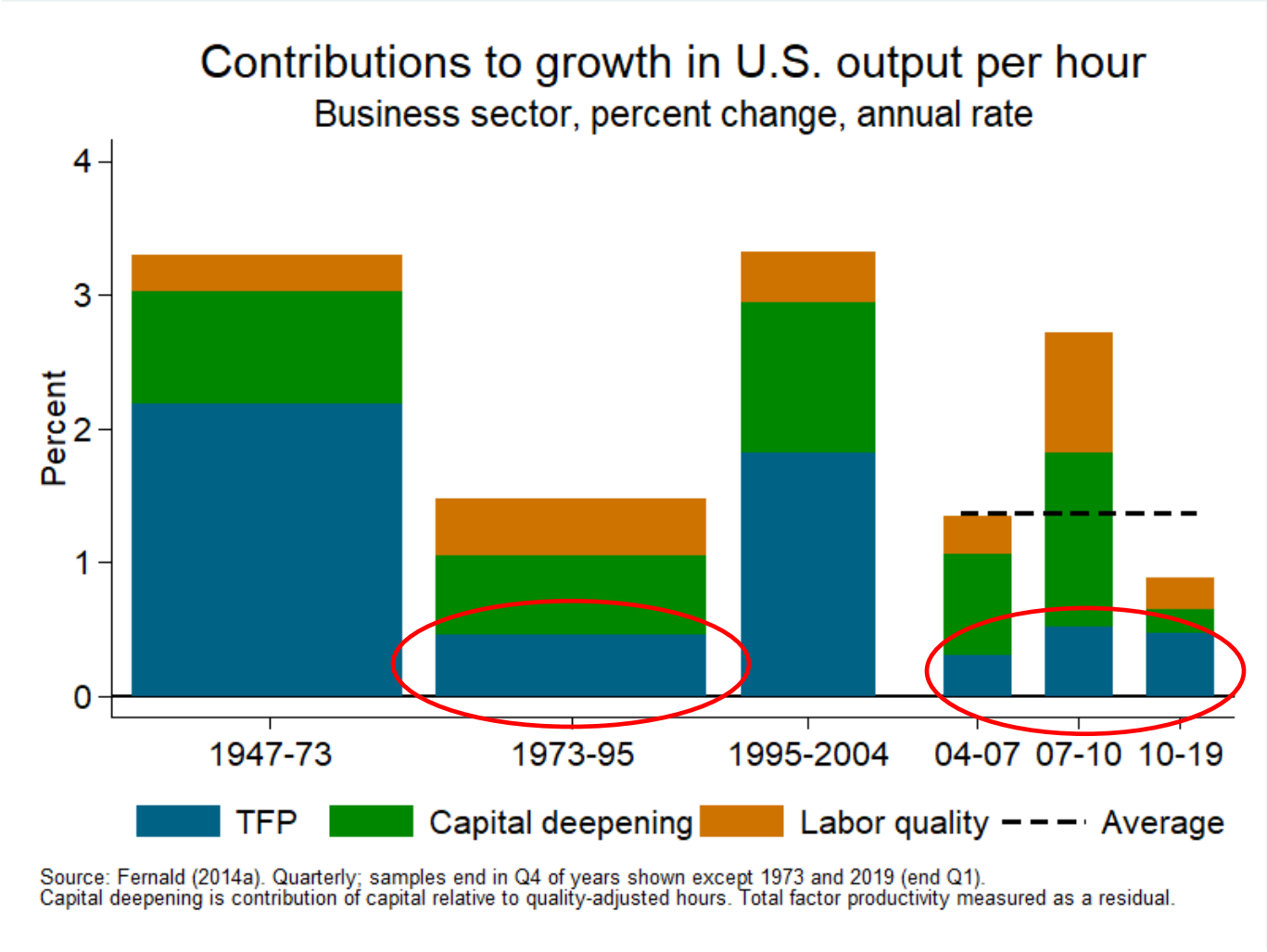
United States

# U.S. productivity growth modest for most of past half century




Source: Fernald (2014a). Quarterly; samples end in Q4 of years shown except 1973 and 2019 (end Q1).

# U.S. TFP growth modest for most of past half century




Source: Fernald (2014a). Quarterly; samples end in Q4 of years shown except 1973 and 2019 (end Q1).
Capital deepening is contribution of capital relative to quality-adjusted hours. Total factor productivity measured as a residual.

# Stories for slow U.S. productivity growth

- Return to “normal” after exceptional IT-linked decade?
  - Unusual period in past half century was late 1990s/early 2000s (Gordon 2016; Fernald 2015)
  - Every story at time emphasized transformative role of IT
- Recession?
  - Intuitive that innovation might fall in recessions (e.g., Anzotegui et al, 2019)
  - But TFP and labor productivity slowed earlier
  - Pre-recession recognition—e.g., Oliner, Sichel, and Stiroh (2007); Jorgenson, Ho, and Stiroh (2008), Fernald et al. (2007)
- Regulation/lack of dynamism?
  - Timing doesn’t work for post-2008 regulation.
  - No apparent link between industry TFP growth and industry-specific regulation (Fernald, Hall, Stock, Watson 2017)
- Mismeasurement got worse?
  - Always had mismeasurement. Little evidence it is worse now (Byrne et al, 2016, Syverson, 2016)

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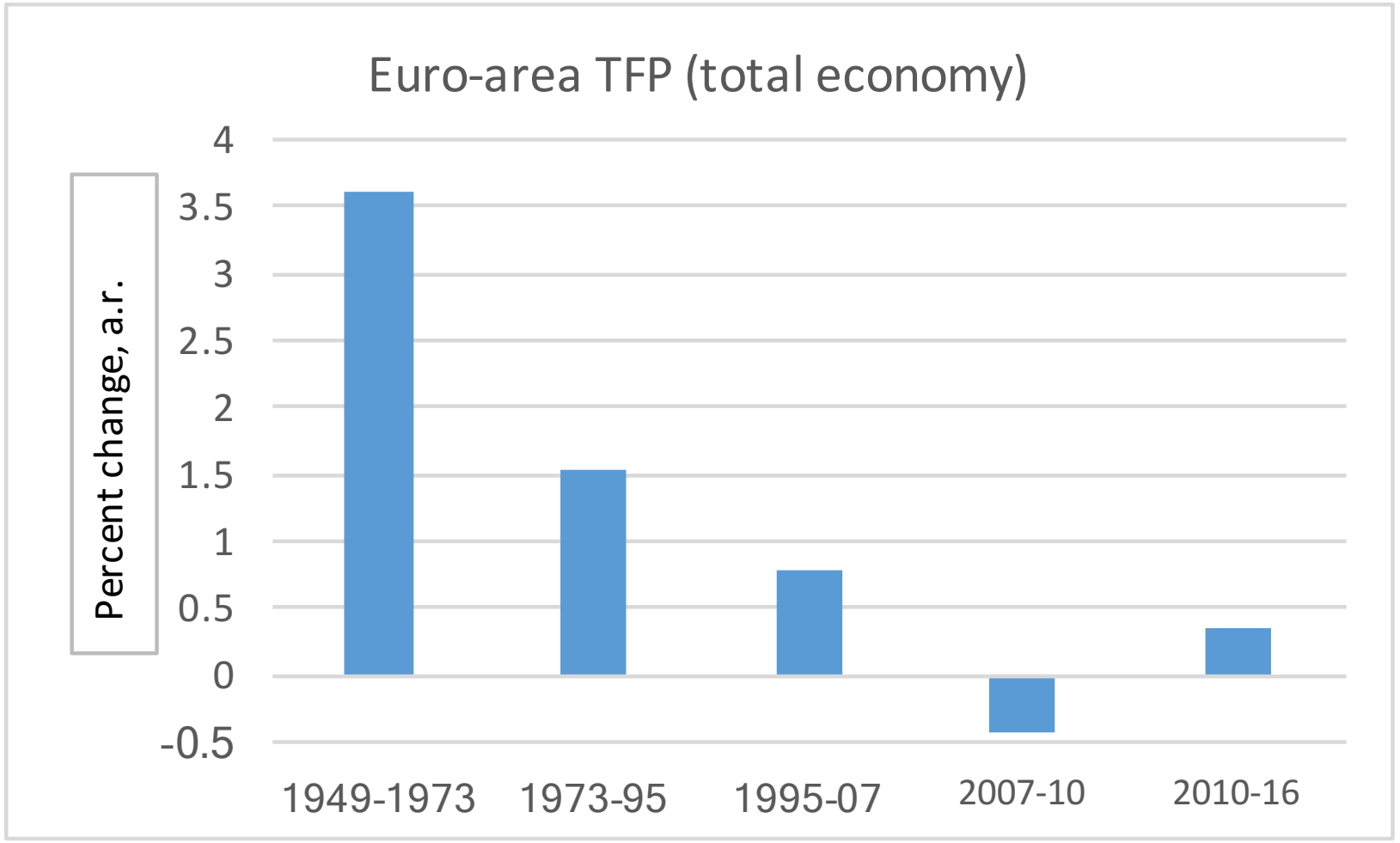
# Falling Euro-area TFP growth




Source: Bergeaud, Cette, and Lecat 2017 (total economy).

# Lessons from advanced economies

- Widespread (across countries and industries) pre-Great-Recession slowdown in TFP growth

# Trends and themes that could be relevant

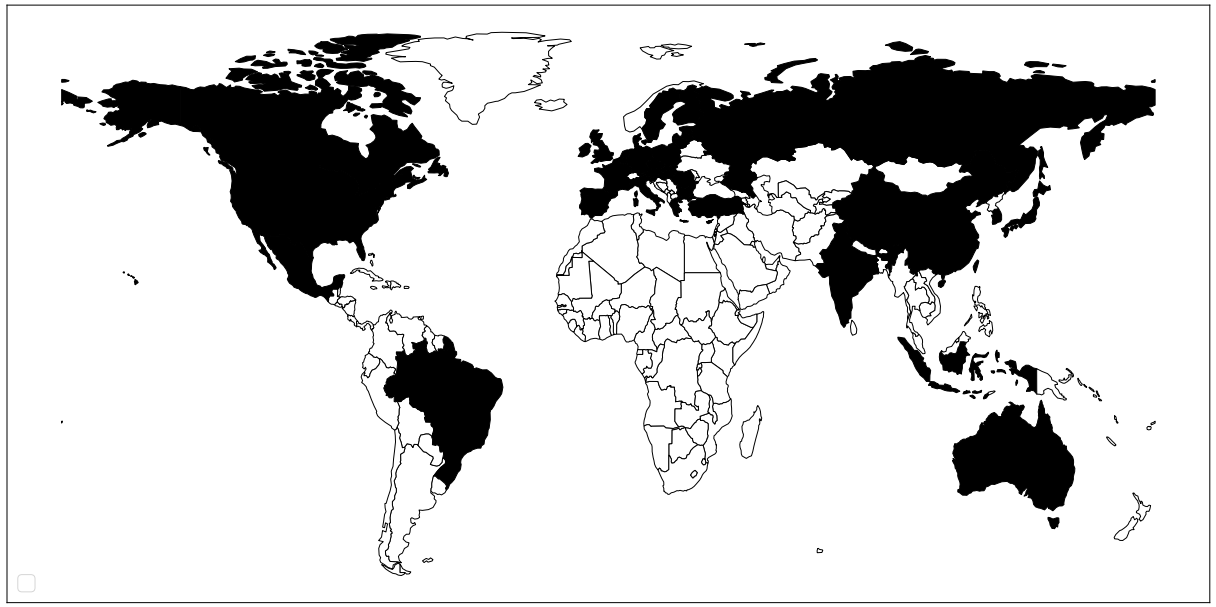
- Rise of the global economy (especially China and India)
- Body of work suggests rising markups/pure profits
  - E.g., De Loecker and Eeckhout (2018); Barkai (2017)
  - With markups, variations in input use (and input-output linkages) affect measured TFP growth
- Misallocation of resources can affect aggregate output
  - E.g., Hsieh-Klenow (2009)

# World Productivity: 1996-2014

(with Esfahani and Hobijn)

# World Input-Output Dataset allows global growth accounting

- 40 countries x 36 industries for 1995-2014 (80% of world GDP)
  - Combine two vintages (2013 and 2016) of WIOD
  - Focus on qualitative results common across vintages
- Have labor productivity and TFP (with some work to extend capital)
- Decompose aggregate productivity into country-industry sources
  - Build on long literature (e.g., Hulten, 1978; Jorgenson et al 1987; Basu and Fernald, 2001,2002)



# Setup

- Each country-industry *i* has a production function.

$$Y_i = F_i\left(K_i, L_i, \{M_{i,j}\}_{j=1}^{n}, Z_i\right)$$

- Distortions: Factor-specific taxes, output taxes, and markup $1 + \mu_i \equiv$ (Price/MC)
- Cost-minim. F.O.C.s imply, e.g.

$$(1 + \mu_i)\ W_i = P_i \frac{\partial Y_i}{\partial L_i}$$

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$$(1+\mu_i)\ W_i = P_i \frac{\partial Y_i}{\partial L_i}$$

$$\Rightarrow (1+\mu_i) \underbrace{\frac{W_i\ L_i}{P_i Y_i}}_{\tilde{s}_i^L} = \frac{\partial Y_i}{\partial L_i}\frac{L_i}{Y_i}$$

# Growth accounting: Output growth depends on growth in inputs and technology

$$Y_i = F_i\left(K_i, L_i, \{M_{i,j}\}_{j=1}^{n}, Z_i\right)$$

- Differentiating production function logarithmically and inserting F.O.C.s implies “Hall (1990) equation”

$$\dot{y}_i = (1+\mu_i)\left(\tilde{s}_i^K \dot{k}_i + \tilde{s}_i^L l_i + \sum_j \tilde{s}_{i,j}^M \dot{m}_{i,j}\right) + \dot{z}_i$$

# Industry value added in presence of markups

- Country-industry value added growth is

$$\dot{v}_i = \frac{P_i Y_i}{P_i^V V_i}\left[\dot{y}_i - \sum_j s_{i,j}^M \dot{m}_{i,j}\right]$$

- Can rewrite gross output growth as

$$\dot{y}_i \equiv \left(\frac{\mu_i}{1+\mu_i}\right)\dot{y}_i + \left(\frac{1}{1+\mu_i}\right)\dot{y}_i$$

Substitute Hall equation here

- Plug into value-added definition

$$\dot{v}_i = s_i^K \dot{k}_i + s_i^L \dot{l}_i + \left(\frac{P_i}{1+\mu_i}\frac{Y_i}{P_i^V V_i}\right)\dot{z}_i + \frac{P_i Y_i}{P_i^V V_i}\left(\frac{\mu_i}{1+\mu_i}\right)\dot{y}_i$$

Markups lead to "extra" value added above contribution of K and L

# Aggregation over country-industries

- Aggregate output is value-added-weighted growth in country-industry value added

$$\dot{v} = \sum_i s_i^V \dot{v}_i, \text{ where } s_i^V \equiv \frac{P_i^V V_i}{PV}$$

# Definition of aggregate TFP

$$\dot{tfp} = \dot{v} - s^K \dot{k} - s^L \dot{l}$$

TFP growth is output growth minus share-weighted input growth

# Plugging in for country-industry value added **(no-markup case)**

$$t\dot{f}p = \dot{v} - s^K\dot{k} - s^L\dot{l}$$

$$= \sum_i s_i^D \dot{z}_i$$

"Pure technology": Domar-weighted aggregate of country-industry TFP growth (Hulten 1978)

$$+ \sum_i s_i^V s_i^K \left(\dot{k}_i - \dot{k}\right) + \sum_i s_i^V s_i^L \left(\dot{l}_i - \dot{l}\right)$$

Misallocation terms (Jorgenson et al, 1987)

$$s_i^D = \frac{P_i Y_i}{P^V V} = \text{"Domar weight"}$$

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Changes in misallocation of capital

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Misallocation terms (Jorgenson et al, 1987)

Changes in misallocation of labor

$$s_i^D = \frac{P_i Y_i}{P^V V} = \text{“Domar weight”}$$

# Markups create an additional term

$$t\dot{f}p = \dot{v} - s^K\dot{k} - s^L\dot{l}$$

$$= \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i$$
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# Markups create an additional term

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"Pure technology": Modified Domar weights

$$= \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i$$
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# Markups create an additional term

$$t\dot{f}p = \dot{v} - s^K\dot{k} - s^L\dot{l}$$

Impact of markups on measured value added growth

$$= \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i$$
$$+ \sum_i s_i^V s_i^K (\dot{k}_i - \dot{k}) + \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l})$$

$s_i^D = \frac{P_i Y_i}{P^V V}$ = "Domar weight"

# NB: With markups/frictions, decomposition is not unique

$$t\dot{f}p = \dot{v} - s^K\dot{k} - s^L\dot{l}$$

$$= \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i$$
$$+ \sum_i s_i^V s_i^K \left(\dot{k}_i - \dot{k}\right) + \sum_i s_i^V s_i^L \left(\dot{l}_i - \dot{l}\right)$$

- Basu and Fernald (2001, 2002): With imperfect competition, social value of industry output depends on who buys it (allocation)
- Expression above isolates different “wedges” (frictions).
  - Baqaee and Fahri (2018) prefer a different aggregation equation, but they have a recent 2019 paper with exactly our expression

# ALP growth = Output per hour growth

$$\dot{a}lp = \dot{v} - \dot{l}$$

# Country-industry-specific labor productivity growth

$$\dot{a}lp = \dot{v} - \dot{l}$$

$$= \sum_i s_i^V \dot{a}lp_i$$

$$+ \sum_i s_i^V (\dot{l}_i - \dot{l})$$

Country-industry specific ALP growth

Reallocation of labor across countries and industries with different levels of labor productivity

# Can separate out labor misallocation term

$$\dot{a}lp = \dot{v} - \dot{l}$$

$$= \sum_i s_i^V \dot{a}lp_i$$

$$+ \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l}) + \sum_i s_i^V (1 - s_i^L)(\dot{l}_i - \dot{l})$$

Net out misallocation-of-labor term from overall reallocation

# World ALP is volatile, but country-industry ALP growth much smoother


World ALP growth is world value-added growth less world growth in hours. Country-industry growth is value-added-weighted growth in country-industry ALP growth.

# Country-industry composition shifting towards emerging markets

**CONTRIBUTIONS TO WORLD ALP GROWTH (P.P. PER YEAR)**

| | 1996-2000 | 2001-2004 | 2005-2007 | 2008-2010 | 2011-2014 |
|---|---|---|---|---|---|
| **Country-industry total** | 2.14 | 2.11 | 2.20 | 1.70 | 0.67 |
| **ADVANCED** | **1.56** | **1.68** | **1.05** | **0.53** | **0.26** |
| US | 0.75 | 1.01 | 0.42 | 0.54 | 0.00 |
| non-US | 0.81 | 0.67 | 0.63 | -0.01 | 0.26 |
| **EMERGING** | **0.58** | **0.43** | **1.15** | **1.17** | **0.41** |
| China | 0.30 | 0.28 | 0.53 | 0.65 | 0.59 |
| India | 0.06 | 0.02 | 0.17 | 0.12 | -0.11 |
| Other | 0.22 | 0.13 | 0.45 | 0.40 | -0.07 |

# Country-industry composition shifting towards emerging markets

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# World ALP is volatile, but country-industry ALP growth much smoother


World ALP growth is world value-added growth less world growth in hours. Country-industry growth is value-added-weighted growth in country-industry ALP growth.

# Labor “misallocation”: Does reallocating labor change output?

$$\dot{a}lp = \dot{v} - \dot{l}$$

$$= \sum_i s_i^V \, \dot{alp}_i$$

$$+ \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l}) + \sum_i s_i^V (1 - s_i^L)(\dot{l}_i - \dot{l})$$

Net out misallocation of labor term from overall reallocation

# Labor “misallocation”: Does reallocating labor change output?

$$\sum_i s_i^V s_i^L (\dot{l}_i - \dot{l})$$

- Suppose fixed aggregate $L$, $K$, and distribution of $K_i$. If redistribute $L_i$:

$$\dot{v} = \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l}) = \sum_i \left(\frac{P_i^V V_i}{PV}\right)\left(\frac{W_i L_i}{P_i^V V_i}\right)\frac{dL_i}{L_i} - \left(\frac{\sum_i W_i L_i}{PV}\right)\dot{l}$$

$$= \left(\frac{1}{PV}\right)\sum_i W_i dL_i$$

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$$\sum_i s_i^V s_i^L (\dot{l}_i - \dot{l})$$

- Suppose fixed aggregate $L$, $K$, and distribution of $K_i$. But distribution of $L_i$ changes:

$$\dot{v} = \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l}) = \sum_i \left(\frac{P_i^V V_i}{PV}\right)\left(\frac{W_i L_i}{P_i^V V_i}\right)\frac{dL_i}{L_i} - \left(\frac{\sum_i W_i L_i}{PV}\right)\dot{l}$$

$$= \left(\frac{1}{PV}\right)\sum_i W_i dL_i$$

- Suppose 2 producers, with $dL_1 = -dL_2$

$$dV = \left(\frac{W_1 - W_2}{P}\right) dL_1$$

# Large part of World ALP growth volatility is labor misallocation

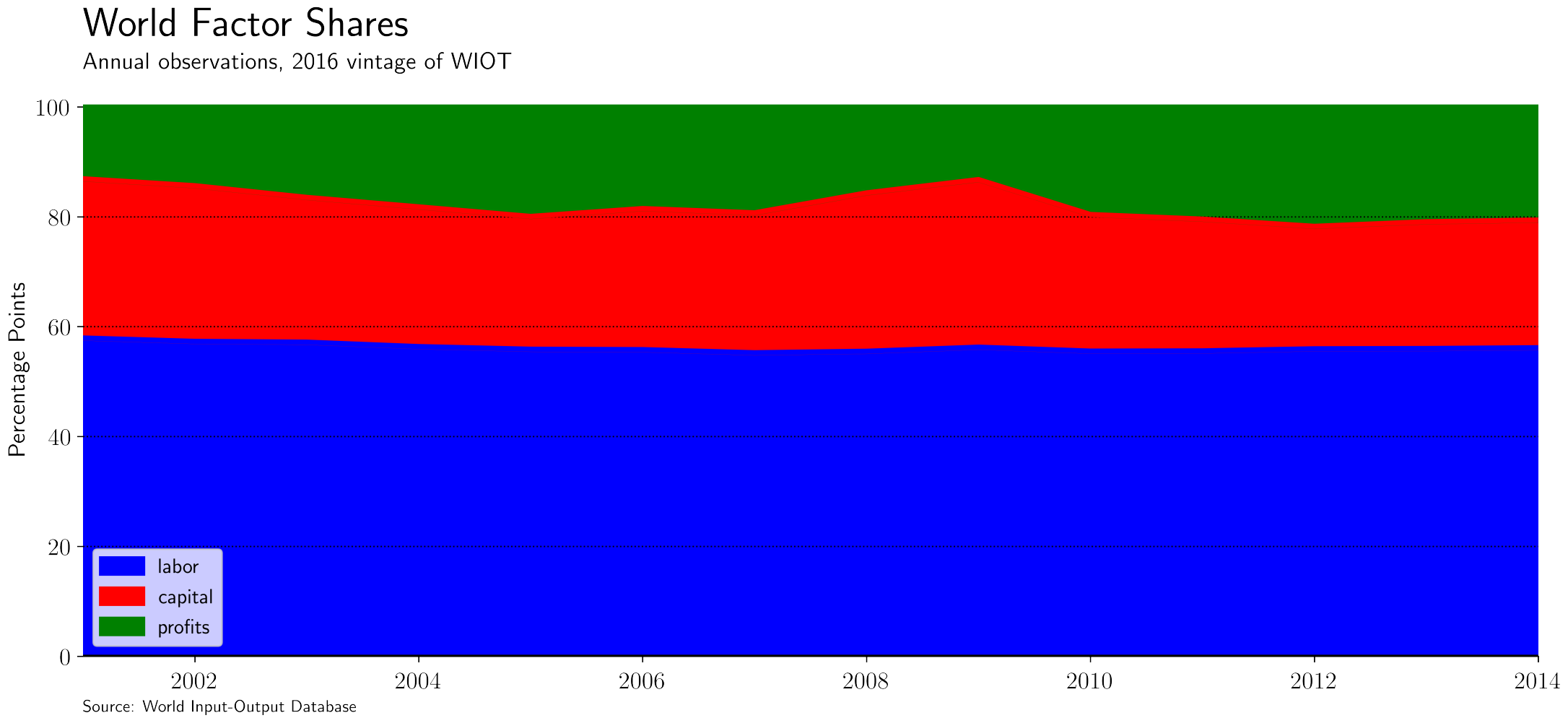
$$\dot{a}lp = \dot{v} - \dot{l}$$
$$= \sum_i s_i^V \dot{alp}_i + \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l}) + \sum_i s_i^V (1 - s_i^L)(\dot{l}_i - \dot{l})$$

| Period | 1996 -2000 | 2001 -2004 | 2005 -2007 | 2008 -2010 | 2011 -2014 |
|---|---|---|---|---|---|
| World ALP growth | 2.15 | 0.07 | 3.31 | 0.98 | -0.82 |
| Country-industry total | 2.14 | 2.11 | 2.20 | 1.70 | 0.67 |
| **Misallocation** | **-0.01** | **-1.34** | **0.50** | **-0.36** | **-0.97** |
| Other reallocation | 0.03 | -0.70 | 0.61 | -0.35 | -0.51 |

# Decomposing further requires markup estimates

- Approach: Assume external nominal "required return" in user cost equation
  - Hall & Jorgenson (1969), Hall (1990), Basu-Fernald (1997), Barkai (2016), Karabarbounis & Neiman (2018)
  - For now: U.S. BBB rate
- Allows us to decompose "residual" payments to capital $\left(1 - s_i^L\right)$ into required payments to capital ($s_i^K$) and pure economic profits. (With CRS), get markups
- Note: Karabarbounas and Neiman (2018) argue that this "profits" term could also reflect risk premia in the user cost, or else intangible capital

# Profits are a sizeable (and rising) share of value added



# Global growth accounting

$$\dot{tfp} = \dot{v} - s^K \dot{k} - s^L \dot{l} = \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i + \sum_i s_i^V s_i^K (\dot{k}_i - \dot{k}) + \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l})$$

| | 96-00 | 01-04 | 05-07 | 08-10 | 11-14 |
|---|---|---|---|---|---|
| World GDP growth | 3.33 | 2.51 | 3.70 | 0.91 | 2.56 |
| World capital growth | 0.79 | 0.74 | 0.80 | 0.75 | 0.63 |
| World hours growth | 0.71 | 1.44 | 0.23 | -0.04 | 1.89 |

# World TFP growth is volatile

$$\dot{tfp} = \dot{v} - s^K \dot{k} - s^L \dot{l} = \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i + \sum_i s_i^V s_i^K (\dot{k}_i - \dot{k}) + \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l})$$

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| World TFP growth | 1.84 | 0.32 | 2.67 | 0.19 | 0.04 |

# No slowdown in country-industry TFP growth before 2007

$$\dot{tfp} = \dot{v} - s^K \dot{k} - s^L \dot{l} = \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i + \sum_i s_i^V s_i^K (\dot{k}_i - \dot{k}) + \sum_i s_i^V s_i^L (\dot{l}_i - \dot{l})$$

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| Country-industry TFP growth | 1.13 | 1.25 | 1.17 | 0.03 | 0.18 |

# Markups important but do not explain slowdown

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| Country-industry TFP growth | 1.13 | 1.25 | 1.17 | 0.03 | 0.18 |
| Shifts in markups | 0.51 | 0.39 | 0.94 | 0.29 | 0.59 |

# Changing misallocation of hours bulk of TFP volatility

$$\dot{tfp} = \dot{v} - s^K \dot{k} - s^L \dot{l} = \sum_i \frac{1}{(1+\mu_i)} s_i^D \dot{z}_i + \sum_i s_i^D \frac{\mu_i}{(1+\mu_i)} \dot{y}_i$$
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| Shifts in markups | 0.51 | 0.39 | 0.94 | 0.29 | 0.59 |
| Misallocation of capital | 0.21 | 0.03 | 0.06 | 0.24 | 0.24 |
| Misallocation of hours | -0.01 | -1.34 | 0.50 | -0.36 | -0.97 |

# Country-industry TFP growth robust to markups

| | With markups | | | | | No markups | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1996-2000 | 2001-2004 | 2005-2007 | 2008-2010 | 2011-2014 | 1996-2000 | 2001-2004 | 2005-2007 | 2008-2010 | 2011-2014 |
| World TFP growth | 1.84 | 0.32 | 2.67 | 0.19 | 0.04 | 1.65 | 0.13 | 2.21 | -0.23 | -0.51 |
| Country-industry total | 1.13 | 1.25 | 1.17 | 0.03 | 0.18 | 0.91 | 1.18 | 1.28 | -0.17 | 0.19 |
| Shifts in markups | **0.51** | **0.39** | **0.94** | **0.29** | **0.59** | -- | -- | -- | -- | -- |
| Misallocation of capital | **0.21** | **0.03** | **0.06** | **0.24** | **0.24** | 0.76 | 0.28 | 0.43 | 0.30 | 0.28 |
| Misallocation of labor | -0.01 | -1.34 | 0.50 | -0.36 | -0.97 | -0.01 | -1.34 | 0.50 | -0.36 | -0.97 |

# Takeaways

- Advanced economy productivity slowed before the Great Recession
  - Will growth pick up? Population is aging, educational attainment adding less, and cyclical boost is behind us…
- Emerging market rise helped maintain global productivity growth for a while
  - Broadening slowdown after 2007 (2010 with labor productivity)
  - Need better data for China and India
- Misallocation of labor and markups important but can't explain slowdown
  - Around half a percentage point of productivity growth may reflect shifting markups
  - Volatility of labor misallocation major source of world productivity volatility
    - (Only partially explained by cost differences across countries)