Intangible Capital and Measured Productivity

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June 2016

(Preliminary draft available at www.econ.umn.edu/∼erm)

Overview

- This paper:
  - Develops a multi-sector model with intangibles
  - Updates BEA IO table to be consistent with theory
  - Estimates processes for *latent* TFPs via MLE
- Main results:
  - New series for sectoral and aggregate TFPs
  - New series for labor wedge

Previous Work

- Business cycle accounting (w/ Chari & Kehoe)
  - Large labor wedge needed to account for US cycles
- Puzzling 1990s hours boom (w/ Prescott)
  - Developed productivity-driven theory of labor wedge
  - Showed source of labor wedge is intangible investment
  - Reconciled small changes in TFP, large changes in hours

Basic Idea

- Shocks to TFPs lead to
  - Fluctuations in investments
  - But, large fraction expensed and not in GDP

$\Rightarrow$ Garbled measure of productivity and time-varying wedge

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- In 1-sector model:

$$\underbrace{\frac{U_l(C_t, 1-H_t)}{U_c(C_t, 1-H_t)}}_{\text{MRS}} \neq \underbrace{(1-\theta)\ \frac{\text{GDP}_t}{H_t}}_{\text{MPL}}$$

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What's New?

- More data available after BEA introduced IPP:
  - Software
  - R&D
  - Entertainment, literary & artistic originals
  - Mineral exploration
  - Other categories likely in future revisions

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- Consider two examples for software
  - Developed and used in-house
  - Sold and bundled with computer equipment
- Tracking the software investments
  - Wages of the software developer
  - Intermediate inputs of manufacturing

Ex. 1: Software Developed and Used In-house

- Old national accounting

Income		Product	
Wages	1,000		
Profits	−1,000		
GDI	0	GDP	0

- New national accounting

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Tracking the IPP: wages of programmers!

Ex. 2: Software Bundled with $2K Computer

- Old national accounting

Income		Product	
Wages	0		
Profits	2,000	Investment	2,000
GDI	2,000	GDP	2,000

- New national accounting

Income		Product	
Wages	0		
Profits	3,000	Investment	3,000
GDI	3,000	GDP	3,000

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Tracking the IPP: intermediate inputs!

Quick Overview of Theory and Estimation

Theory

- S sectors with technologies:

$$Y_{st} = (K^1_{Tst})^{\theta_s}(K_{Ist})^{\phi_s}(\prod_l (M^1_{lst})^{\gamma_{ls}})(Z^1_{st}H^1_{st})^{1-\theta_s-\phi_s-\gamma_s}$$

$$X_{Ist} = (K^2_{Tst})^{\theta_s}(K_{Ist})^{\phi_s}(\prod_l (M^2_{lst})^{\gamma_{ls}})(Z^2_{st}H^2_{st})^{1-\theta_s-\phi_s-\gamma_s}$$

  where

  Y, X_I: outputs of tangible, intangible goods & services

  K_T, K_I: tangible, intangible capital stocks

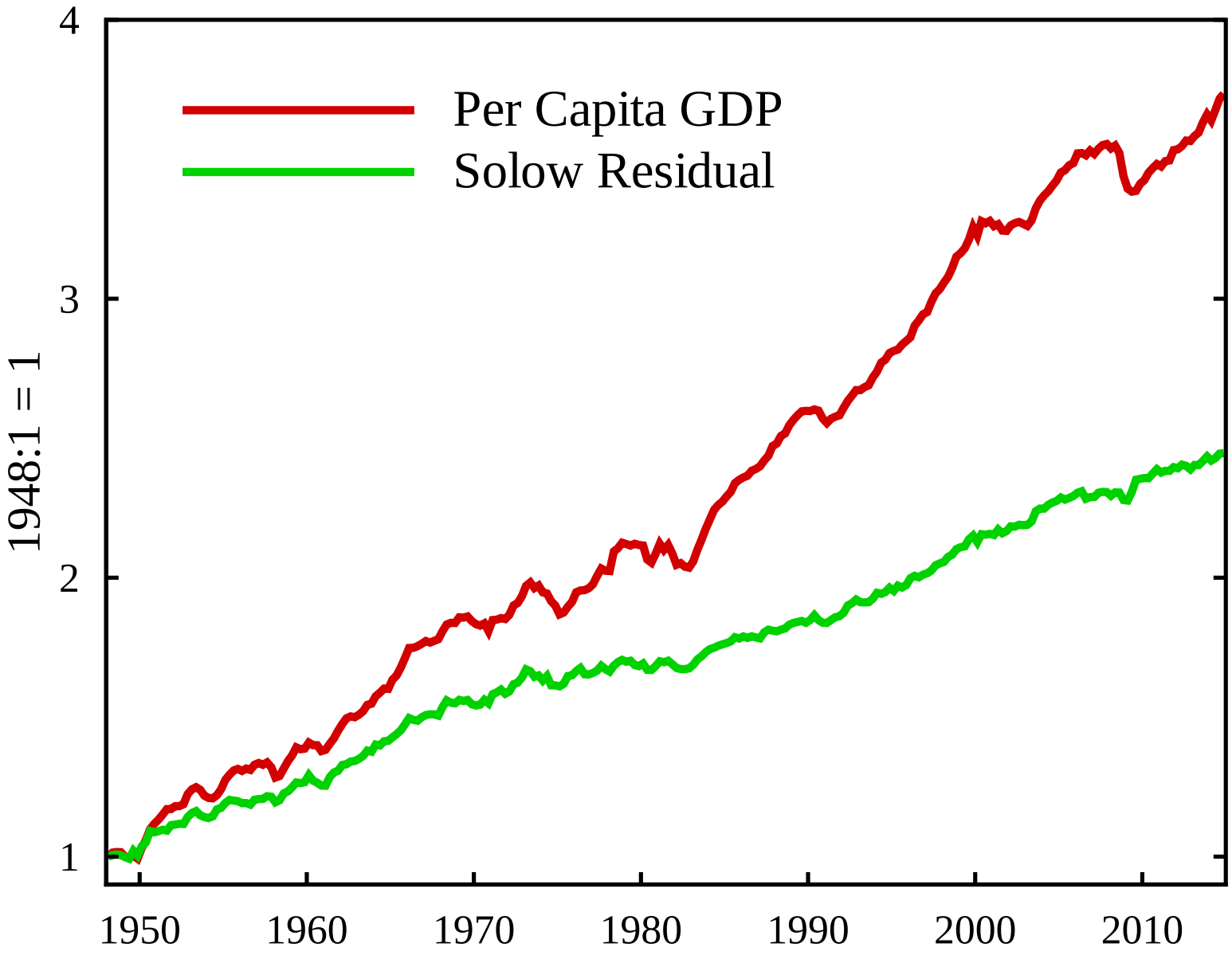
  H: hours

  M: intermediate inputs

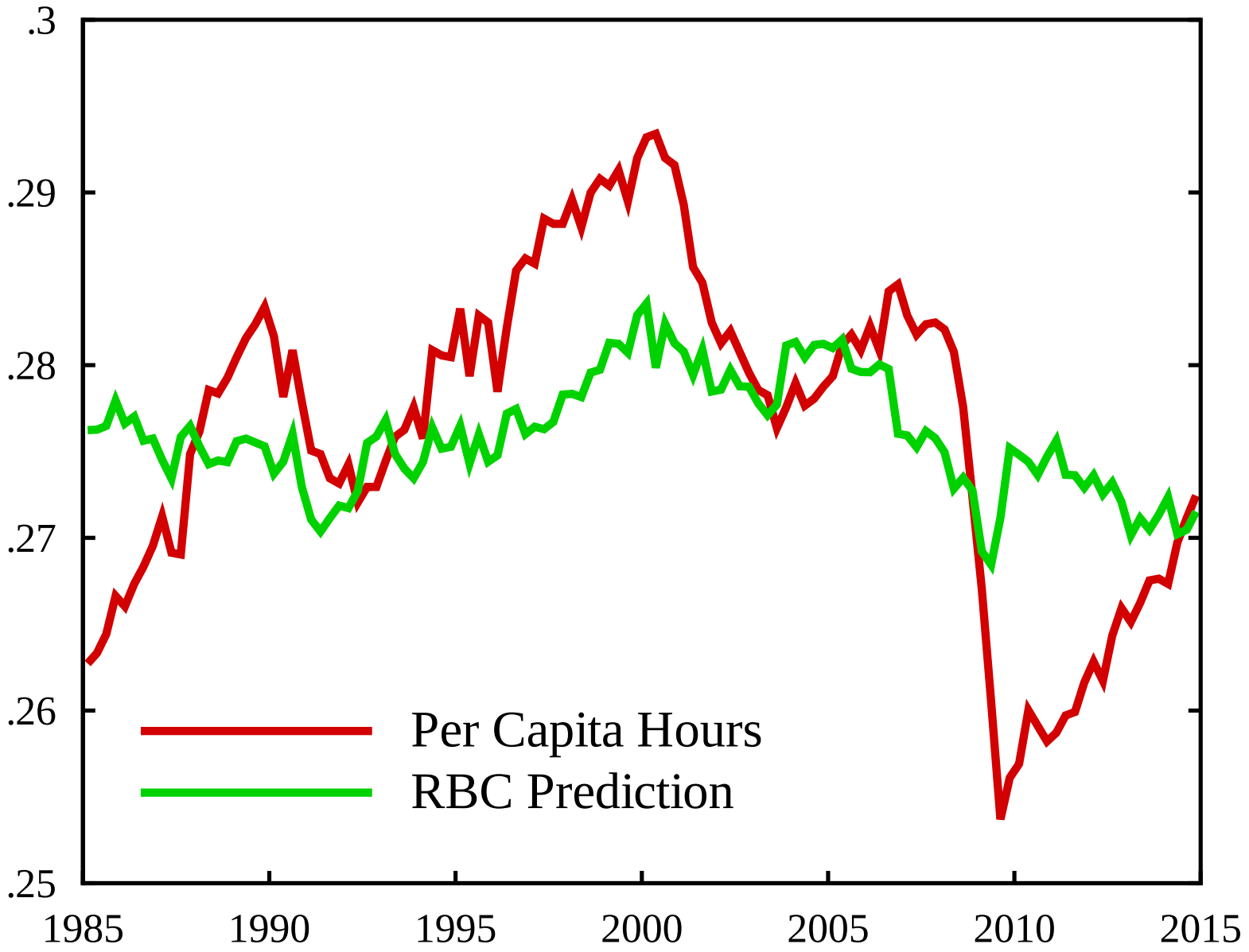
  Z: technology parameters

- Everything else is standard neoclassical growth model

Simplest RBC with $Y_t = A_t K_t^{\theta} H_t^{1-\theta}$



Simplest RBC Needs Large Labor Wedge



Updated RBC

- Currently have 15 major NAICS sectors
  - 12 with variations in only Z^1
  - 3 with variations in both Z^1, Z^2
    - Manufacturing (R&D-intensive)
    - Information (ICT-intensive)
    - Professional business (Tech service-intensive)
- Use updated IO table to parameterize production shares
- Later: will introduce variation in other Z^2's

MLE Estimation

- State-space system after computing equilibrium:

$$x_{t+1} = A(\Gamma)x_t + B(\Gamma)\epsilon_{t+1}$$
$$y_t = C(\Gamma)x_t$$

  - x_t= latent model state variables
    = capital stocks, exogenous TFPs (the Z's)
  - y_t= observations
    = industry gross outputs plus hours for X_I-intensive
  - Γ = pre-set parameters (mostly from new IO table)

- Estimate processes for $\{Z^1_{st}\}$, $\{Z^2_{st}\}$ (18 in all)

Processes for TFP Shocks

- Model as separate AR processes with uncorrelated errors:

$$\begin{aligned}
\log Z^i_{jt} &= \log \tilde{Z}^i_{jt} + \varphi_j \log Z_t \\
\log \tilde{Z}^i_{jt} &= \rho^i_j \log \tilde{Z}^i_{jt} + \epsilon^i_{jt} \\
\log Z_t &= \rho \log Z_t + \upsilon_t, \quad E\epsilon^i_{jt}\upsilon_t = 0
\end{aligned}$$

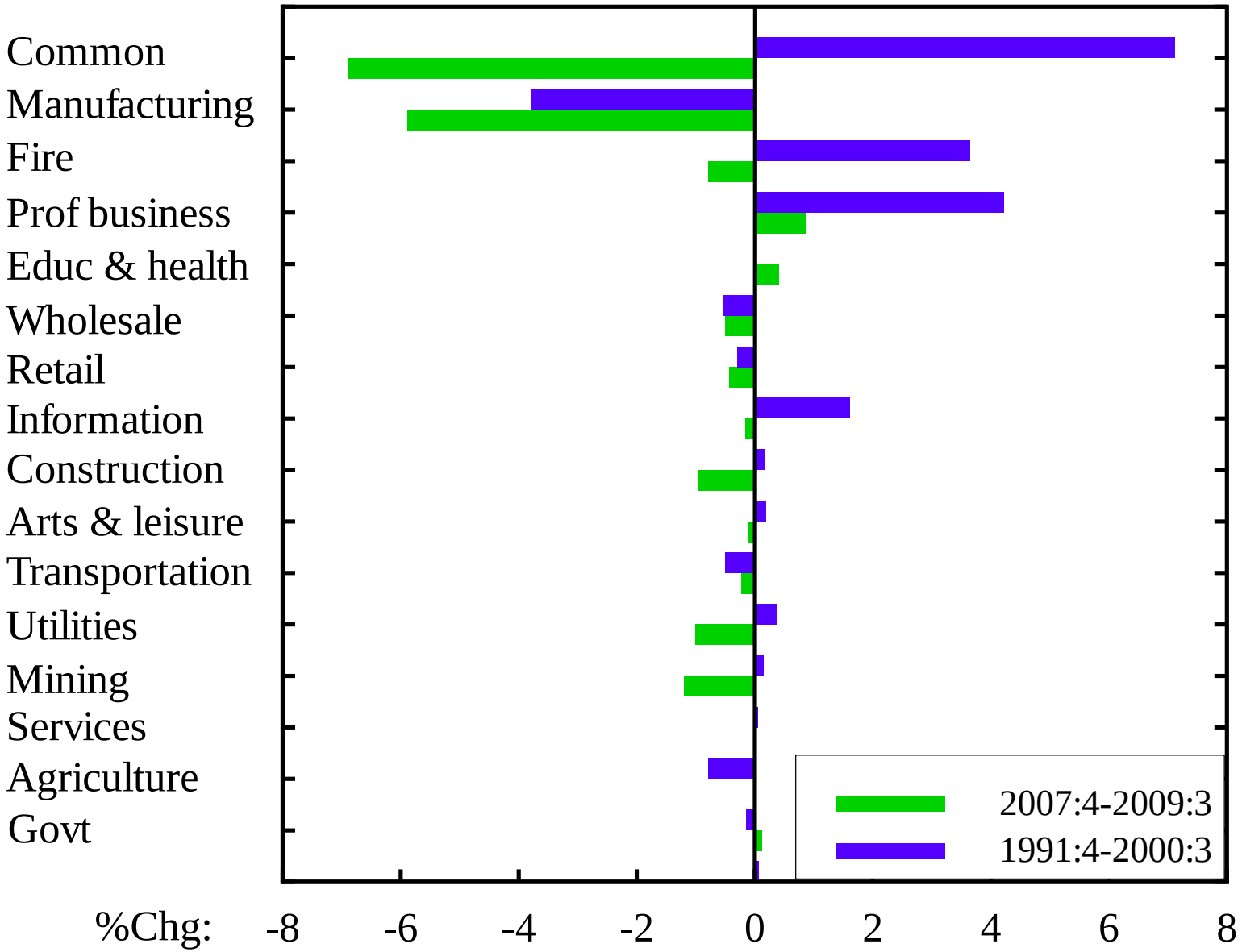
- Estimate ρ^i_j, φ_j, ρ, and shock variances

Main Results

What Shocks are Most Important?

- Typically, want to compute variance decompositions
- Here,
  - Sectoral trends are included
  - Sample too short for computing ergodic distribution
- Instead, report contributions of shocks for 2 periods

Decomposing Changes in Gross Output



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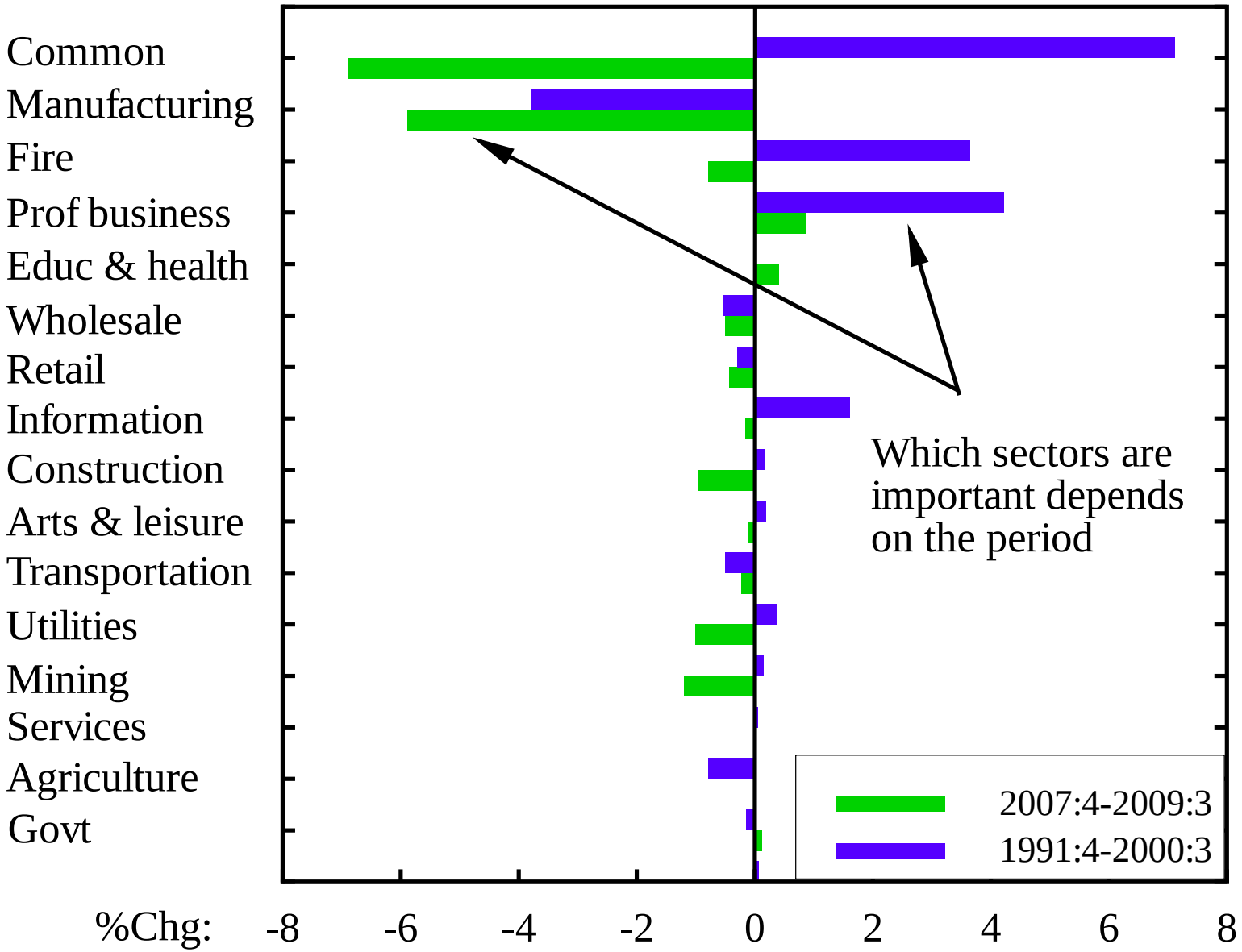


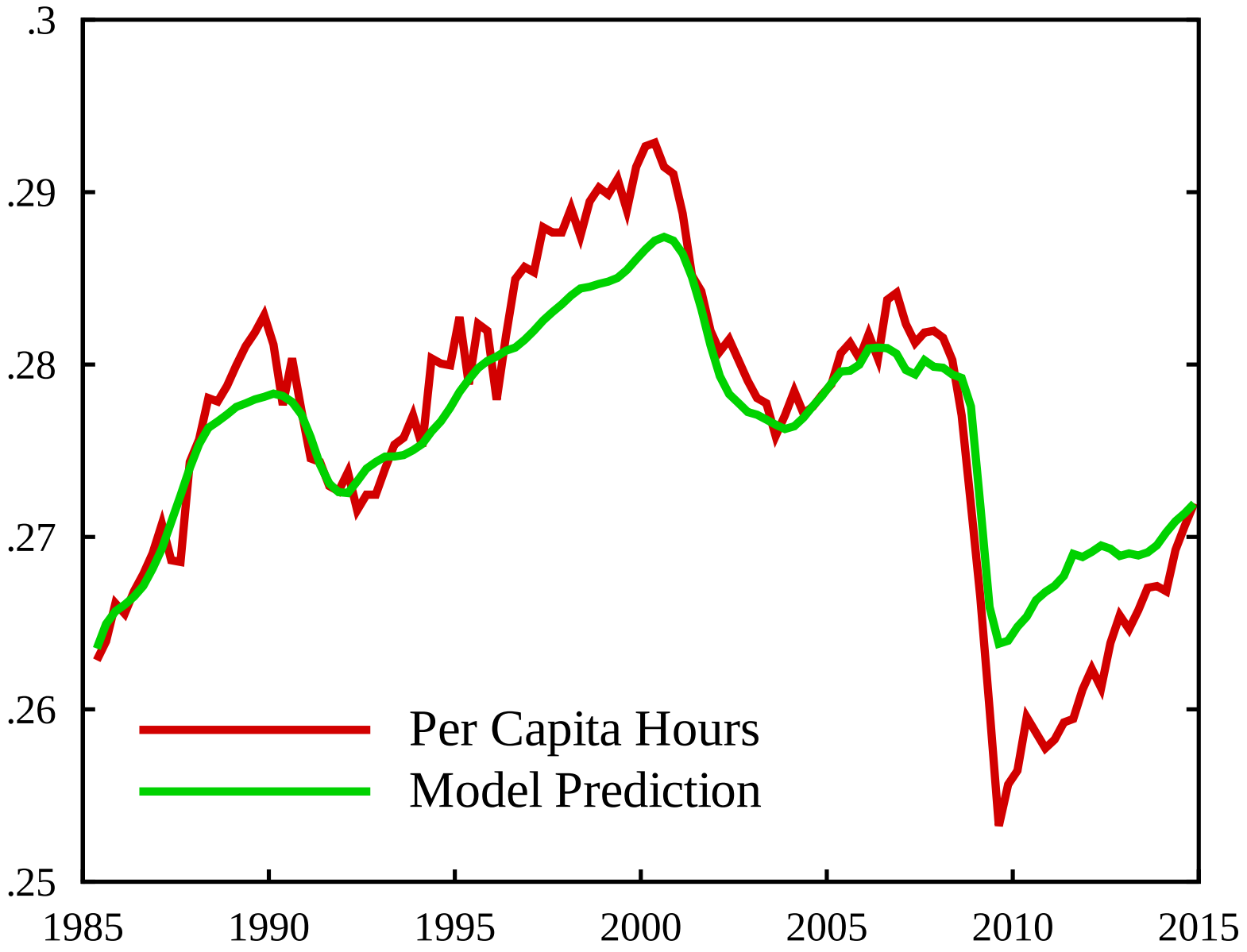
Prediction for Hours

- Recall:
  - Total hours not included with observables
  - Only hours in 3 X_I-intensive sectors ($\sim$10% of total)

  $\Rightarrow$ An external check on updated theory

- Is a large labor wedge still needed?

Updated RBC Needs Much Smaller Labor Wedge



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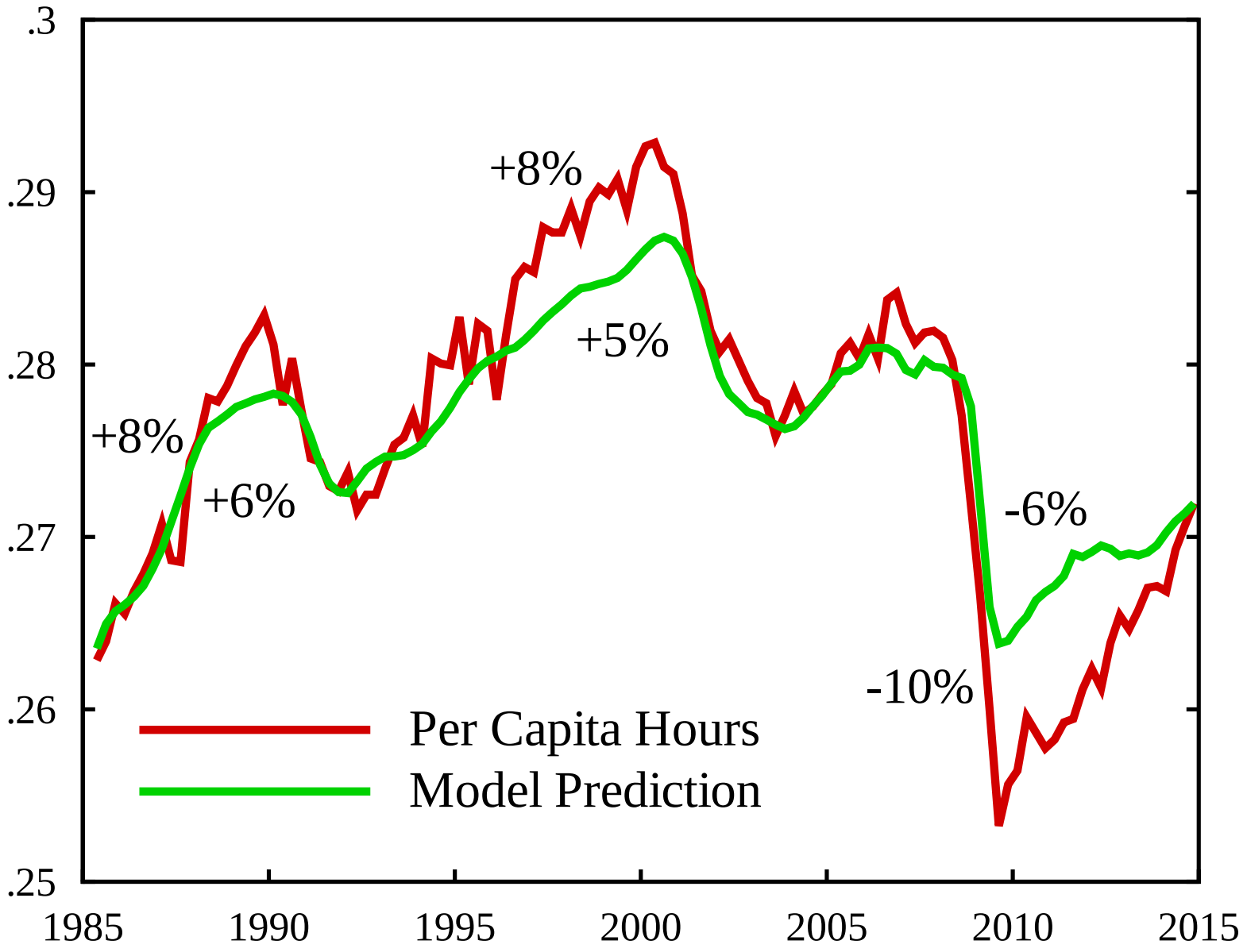
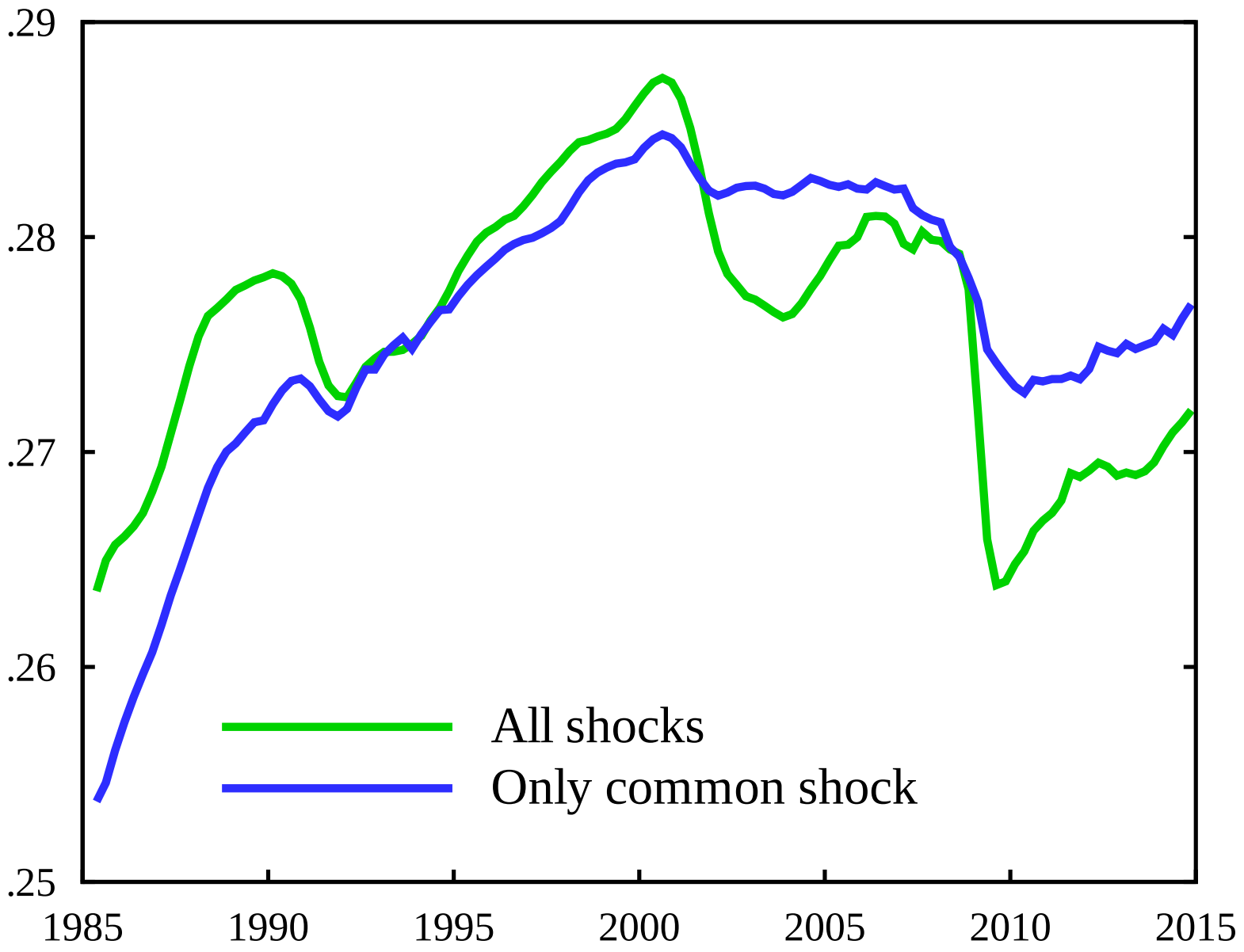
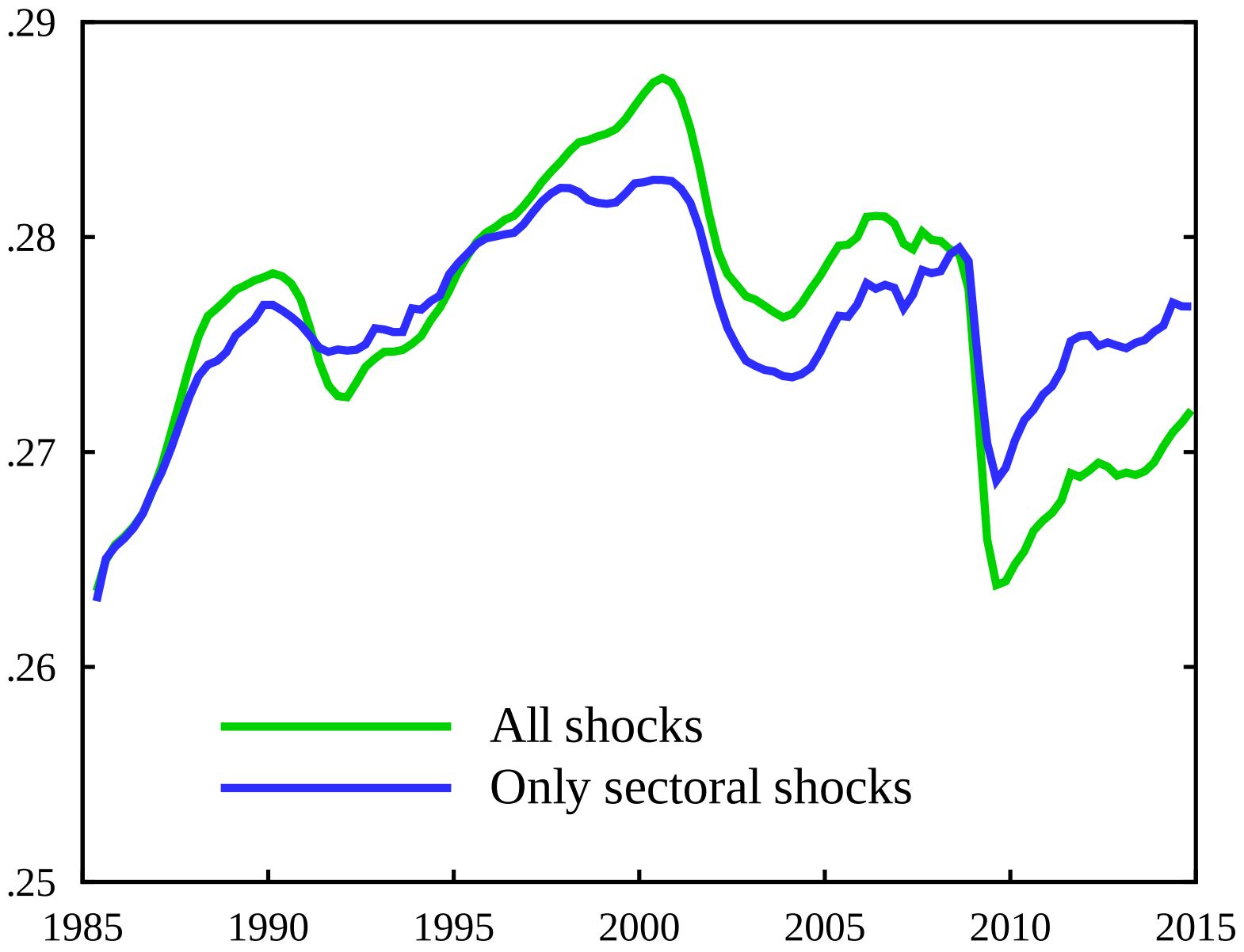


Hours with Only Common Shock



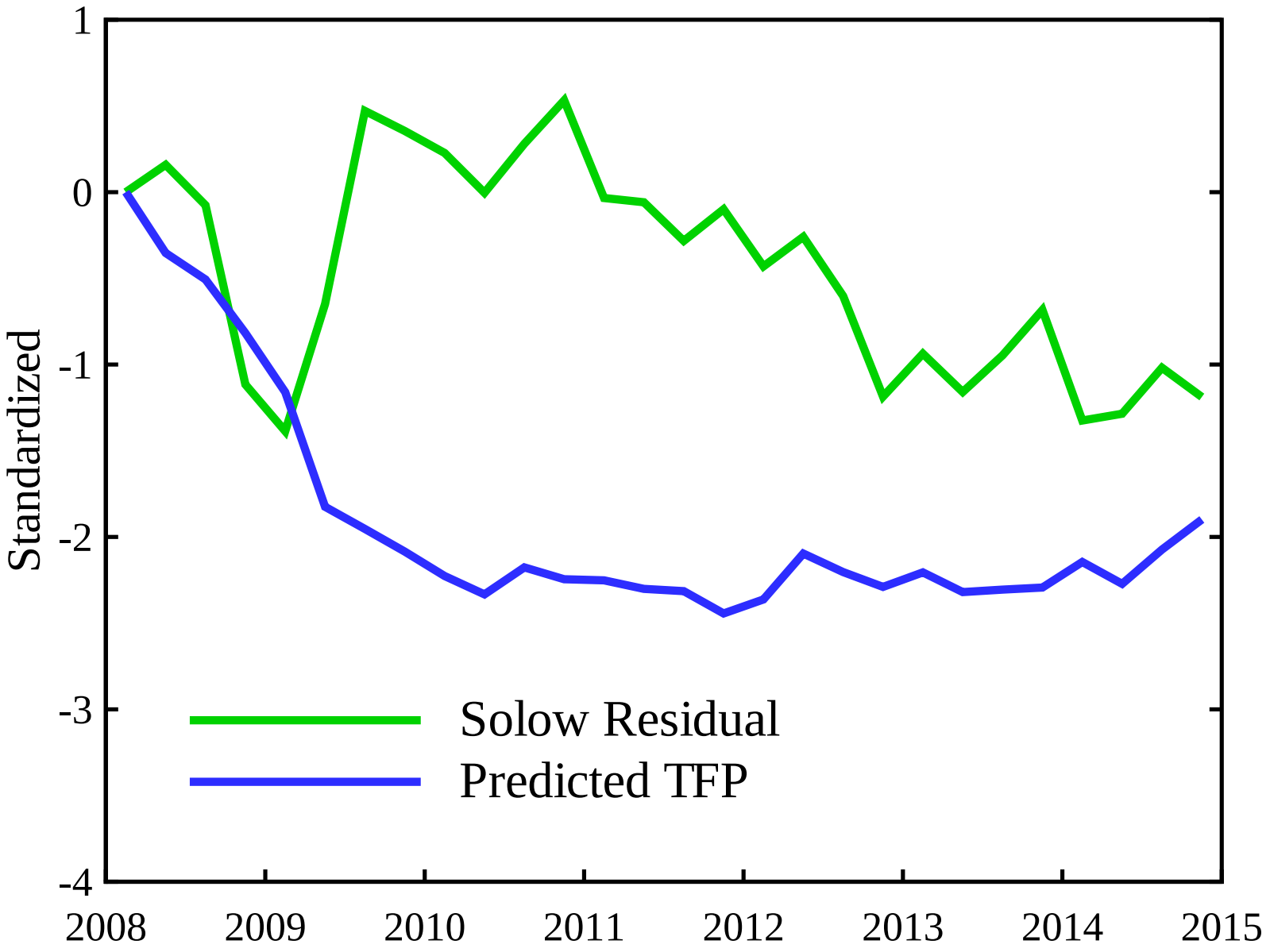
Hours with Only Sectoral Shocks



Solow Residual vs. Common TFP Shock

- Compare time paths:
  - Measured Solow residual
  - Predicted common TFP shock (Z)
- Correlations of series, logged and:
  - Geometrically detrended: 73%
  - HP-filtered: 9%
- Next, consider Great Recession period

A Closer Look at the Great Recession



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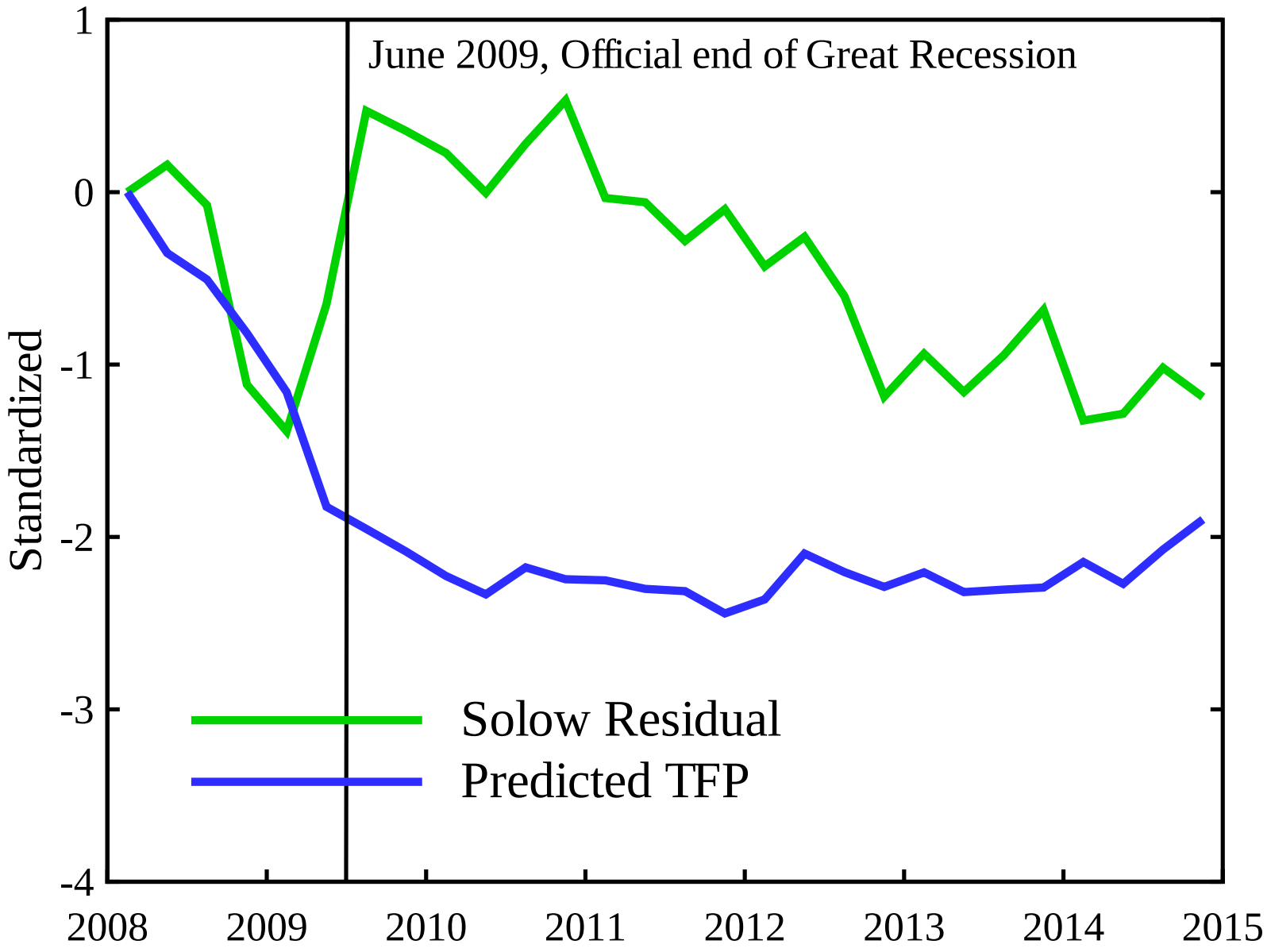

Summary

- Both theory and data expanded to include intangibles
- Estimated new TFP series
- MLE estimates consistent with
  - Smaller role for unexplained labor wedges
  - Larger role for sector-specific shocks and linkages
- Next step: disaggregate certain sectors further