Aggregate Implications of Changing Sectoral Trends

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Introduction

- Slow GDP growth post-2009 is due to slow growth in TFP and labor, and is unrelated to the Financial Crisis, Fernald, et al (2017).
- The trend of US GDP growth declined steadily over the entire post-WW II period.
- Was this decline in aggregate GDP trend growth due to common or sector-specific factors?
- Which sectors contributed the most to the aggregate GDP trend growth decline?

Overview of the Paper

- Decompose sector-level TFP and labor growth
  - Common trends and transitory changes.
  - Sector-specific trends and transitory changes
- Incorporate these components into a dynamic multi-sector framework.
  - New theoretical results: sectoral multipliers.
- Virtually all of the long-run decline in GDP growth results from sector-specific rather than common trends.
  - Key sectors are Construction, Non-durable Goods, and Professional and Business Services, ...
  - with a temporary off-set coming from Durable Goods.

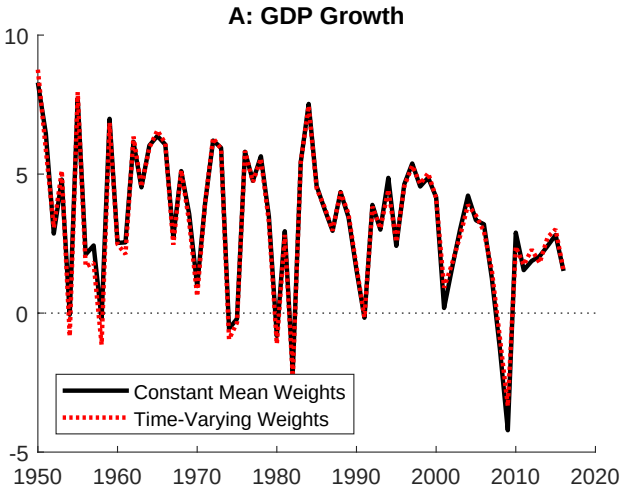
Multi-Sector Models

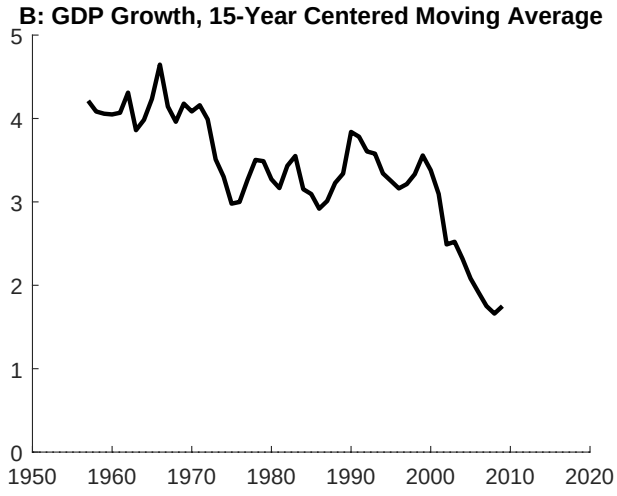
- Early literature on multi-sector growth models: Long and Plosser (1983), Horvath (1998), Dupor (1999).
- More recently: Gabaix (2011), Foerster et al. (2011), Acemoglu et al. (2012), Atalay (2017), Bigio and La'o (2018), Miranda-Pinto and Young (2018), Miranda-Pinto (2018), Baqaee and Farhi (2018a, 2018b).
- Main focus of this literature: The amplification of volatility.
- Focus today: Structural change and secular growth.

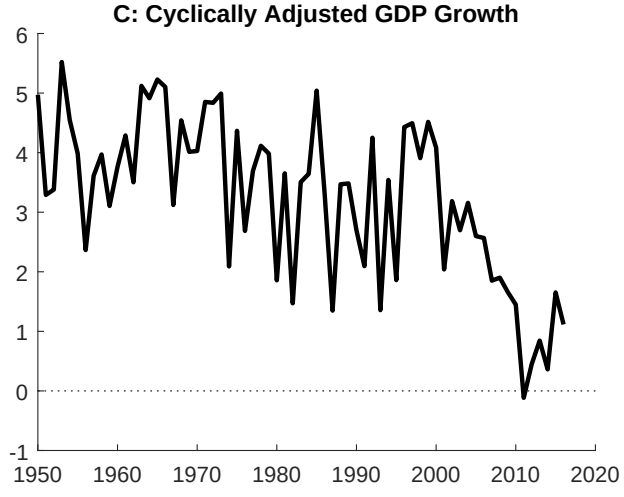
Data

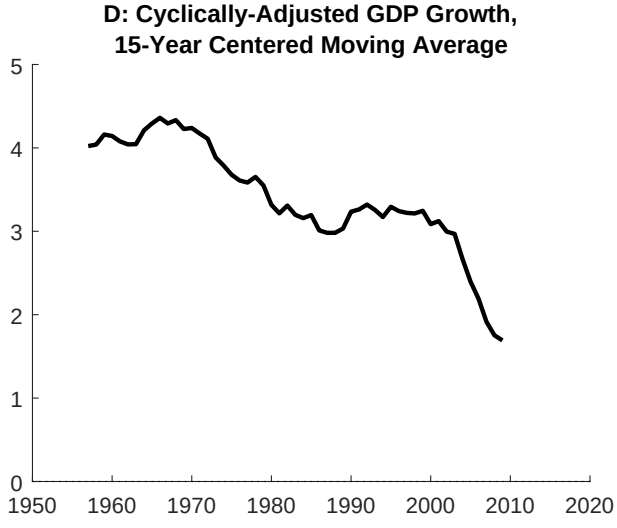
- Merge industry KLEMS data from Jorgenson et al and BEA's Industry Level Production Accounts
  - Annual data from 1950 to 2016
- Aggregate 61 private industries to 16 sectors
- Aggregate the 16 sectors to GDP
- Pre-filter the data: cyclical adjustment using unemployment rate

U.S. GDP Growth Rates, 1950-2016









U.S. GDP Growth - 15-Year Averages

Dates	Growth rates	Cyclically-adjusted growth rates
$1950-2016$	3.3	3.2
$1950-1965$	4.3	4.1
$1966-1982$	3.1	3.7
$1983-1999$	3.9	3.3
$2000-2016$	1.8	1.9

Balanced Growth in the 1-Sector Model

- Suppose $V_t = \left(z_t L_t^{1-\alpha}\right) K_t^{\alpha} = A_t K_t^{\alpha}$. Along a BGP,

$$\Delta \ln V = \Delta \ln A / (1-\alpha)$$

- This balanced growth intuition motivates our focus on the basic inputs, TFP and labor.

- From $1950-2016$, average growth rates and capital income shares are $\Delta \ln z = 0.6\%$, $\Delta \ln L = 1.5\%$, and $\alpha = 0.43$.

- The implied GDP growth rate on the BGP is $\Delta \ln V = 2.6\%$, but actual (average) GDP growth is 3.3%. We are missing 70 basis points!

- Linkages between sectors, unaccounted for in the standard model, matter for growth.

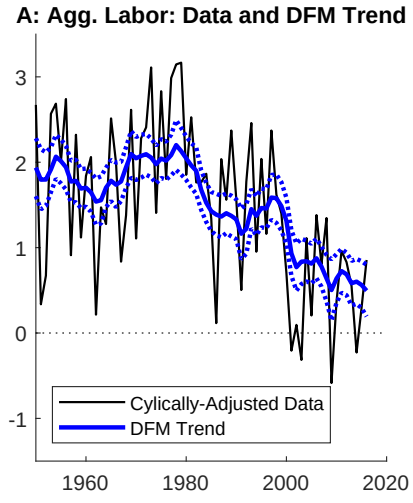
Empirical Framework

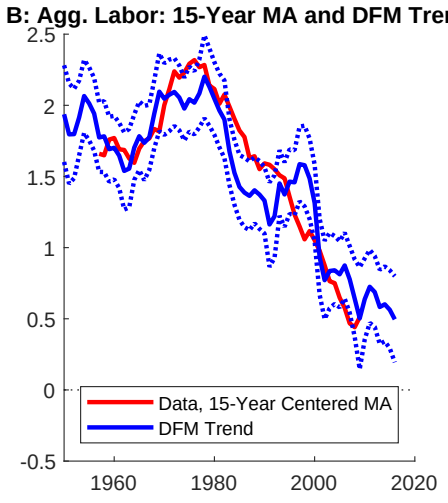
- For TFP or labor, $x = z$ or L,

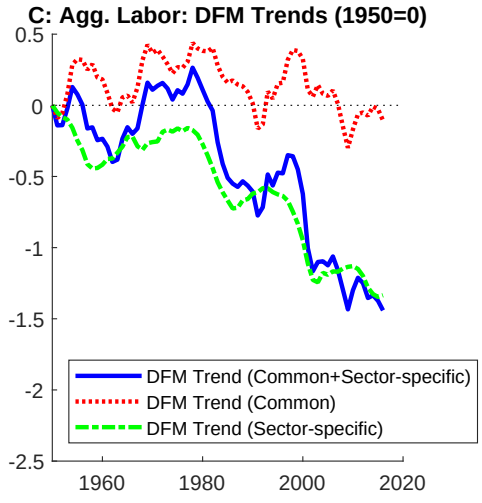
$$\Delta \ln(x_{j,t}) = \lambda_{j,\tau}\tau_{c,t} + \lambda_{j,\varepsilon}\varepsilon_{c,t} + \tau_{j,t} + \varepsilon_{j,t},$$

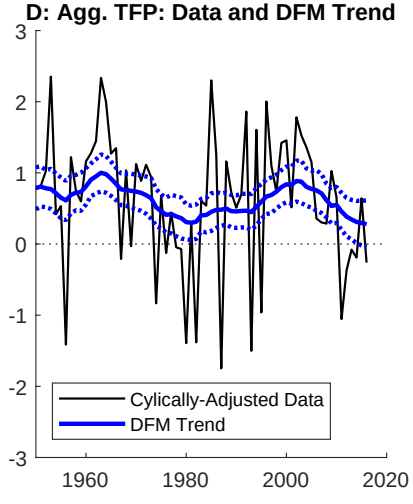
- Common trend, $\tau_{c,t} = \tau_{c,t-1} + \sigma_{\Delta,c} \cdot \eta_{\tau,c,t}$
- Sector-specific trend, $\tau_{j,t} = \tau_{j,t-1} + \sigma_{\Delta,j} \cdot \eta_{\tau,j,t}$
- Common transitory shock, $\varepsilon_{c,t}$ iid
- Sector-specific transitory shock, $\varepsilon_{j,t}$ iid
- The model is estimated using a Gibbs sampler.

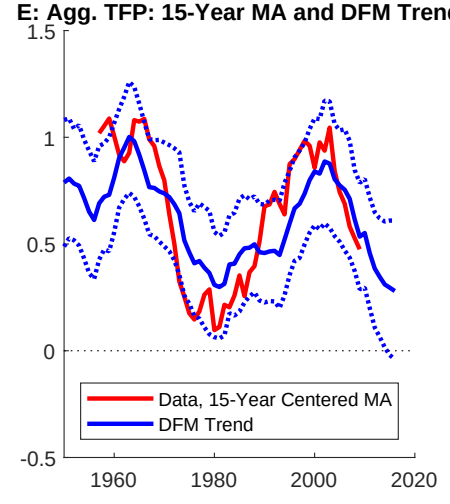
Aggregate Trend Growth Rate in Labor and TFP

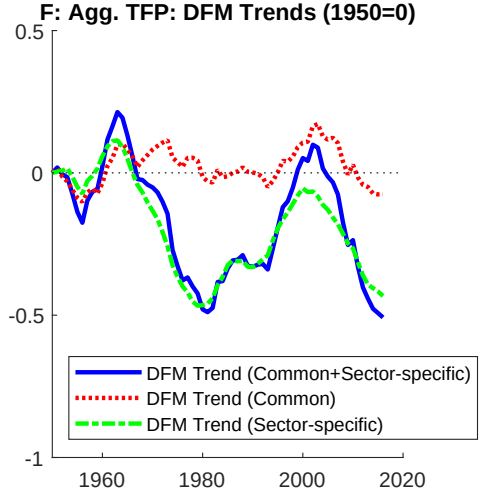




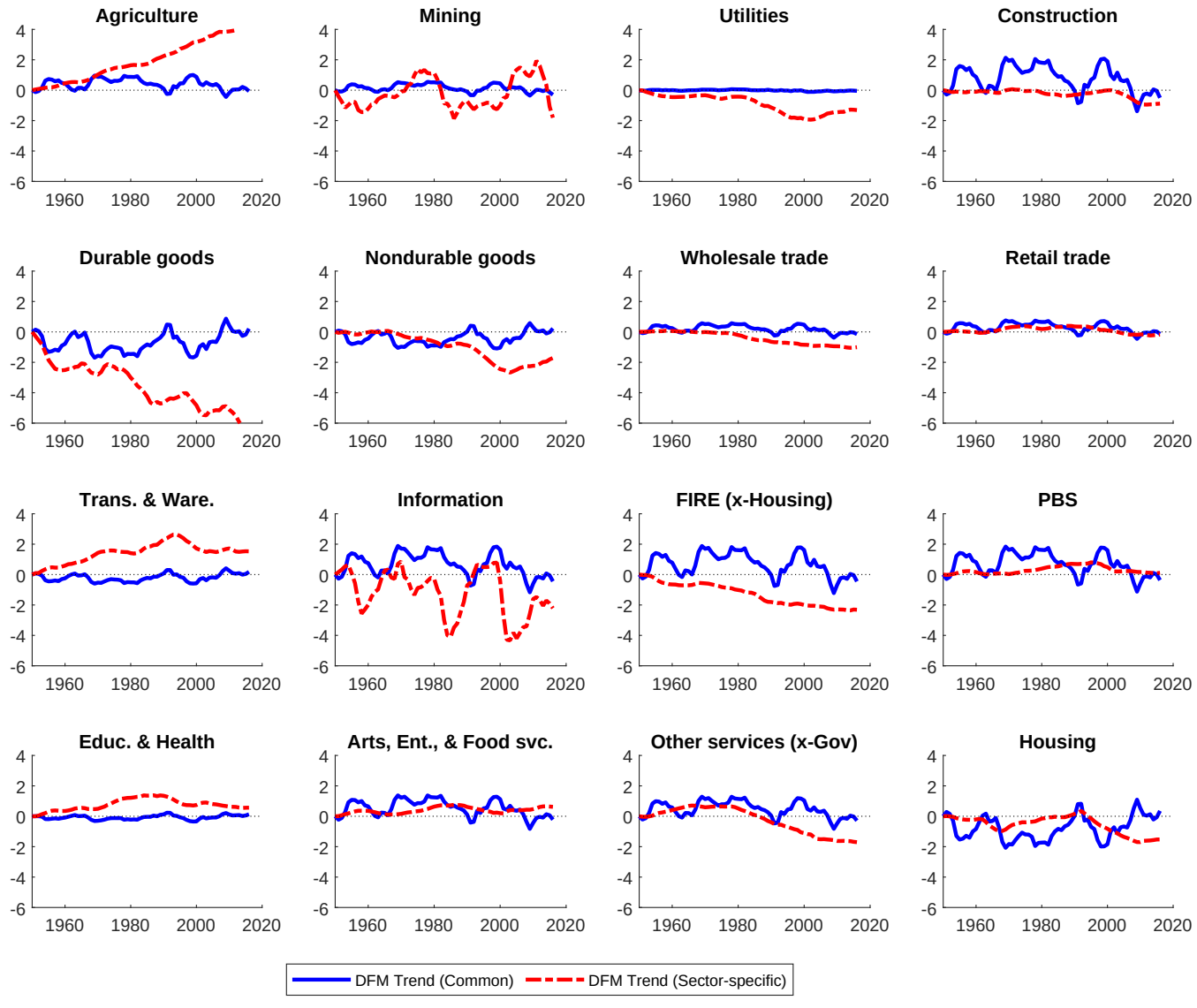




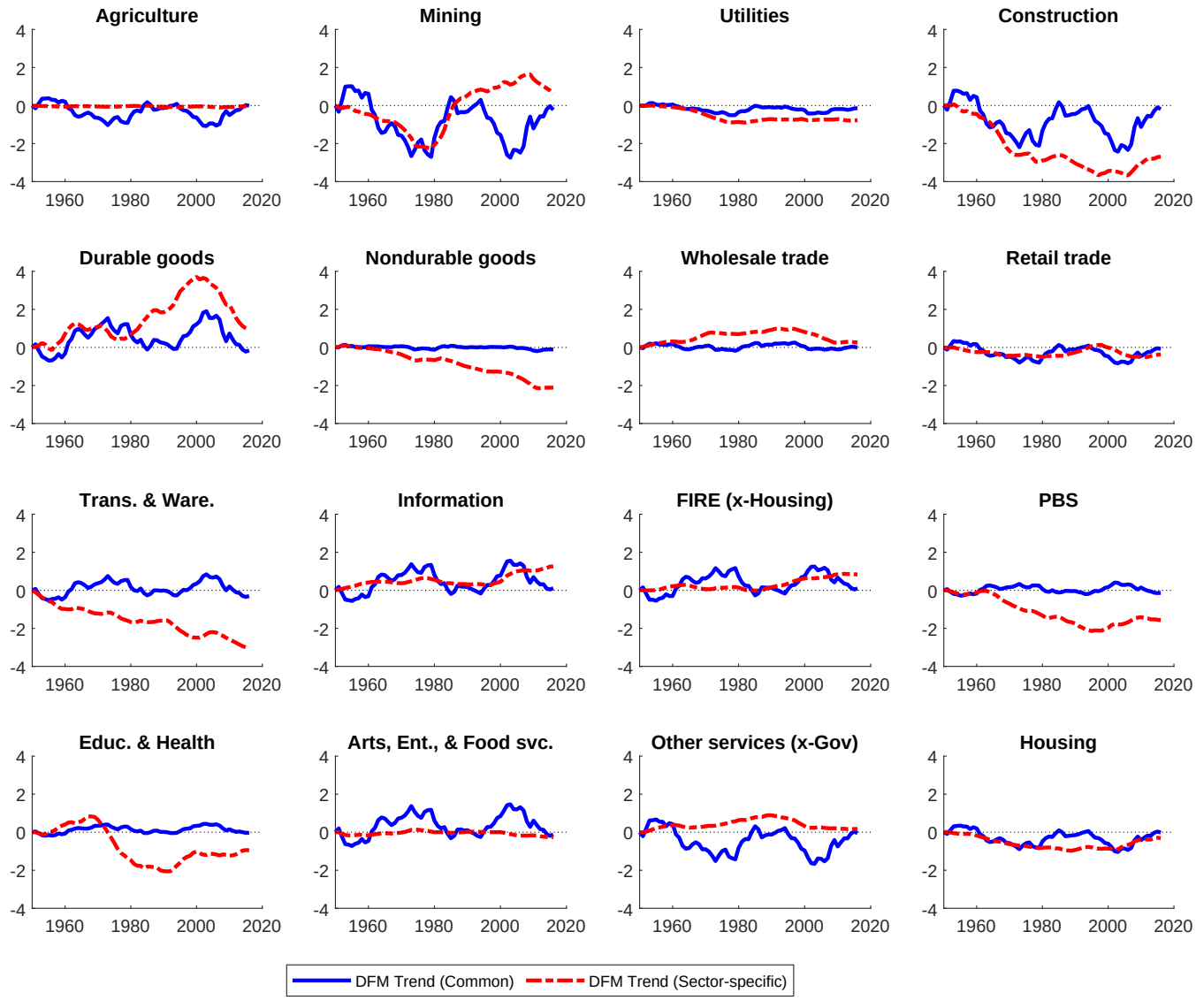




Sector-Specific and Common Labor Trends



Sector-Specific and Common TFP Trends



Structural Change and the Aggregate Economy

- We define structural change as changes in trend growth rates of sectoral TFP and labor.
- Structural change in one sector can have implications for growth in every other sector, because ...
- Sectors are linked–materials and capital used in one sector are produced in other sectors.
- Analysis of how changes in one sector affects other sectors - and in turn affect aggregates - requires a structural framework.
- We consider: a dynamic environment, unit-elastic technologies and preferences, competitive input and product markets, explicit linkages between sectors in materials and capital.

A Multi-Sector Economy

- n distinct sectors of production, indexed by j (or i).
- Preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \prod_{j=1}^{n} \left(\frac{c_{j,t}}{\theta_j} \right)^{\theta_j}, \ \sum_{j=0}^{n} \theta_j = 1, \ \theta_j \geq 0$$

- Gross output production

$$y_{j,t} = \left(\frac{v_{j,t}}{\gamma_j} \right)^{\gamma_j} \left(\frac{m_{j,t}}{1-\gamma_j} \right)^{(1-\gamma_j)}, \ \gamma_j \in [0,1]$$

- Value added production

$$v_{j,t} = z_{j,t} \left(\frac{k_{j,t}}{\alpha_j} \right)^{\alpha_j} \left(\frac{\ell_{j,t}}{1-\alpha_j} \right)^{1-\alpha_j}, \ \alpha_j \in [0,1]$$

Network Linkages Between Sectors

- Materials bundle

$$m_{j,t} = \prod_{j=1}^{n} \left(\frac{m_{ij,t}}{\phi_{ij}} \right)^{\phi_{ij}}, \ \sum_{i=1}^{n} \phi_{ij} = 1, \ \phi_{ij} \geq 0$$

  - Input-Output (IO) matrix is an $n \times n$ matrix $\Phi = [\phi_{ij}]$.

- Investment bundle

$$x_{j,t} = \prod_{j=1}^{n} \left(\frac{x_{ij,t}}{\omega_{ij}} \right)^{\omega_{ij}}, \ \sum_{i=1}^{n} \omega_{ij} = 1, \ \omega_{ij} \geq 0$$

  - Capital Flow matrix is an $n \times n$ matrix $\Omega = [\omega_{ij}]$.

Resource Constraints

- Goods market clearing

$$c_{j,t} + \sum_{i=1}^{n} m_{ji,t} + \sum_{i=1}^{n} x_{ji,t} = y_{j,t}$$

- Capital accumulation

$$k_{j,t+1} = x_{j,t} + (1 - \delta_j) k_{j,t}$$

Sectoral Structural Change (I)

- Calibrate shares and other structural parameters based upon BEA input-output and capital flow tables.

- Sectoral structural change is represented by the variable $A_{j,t}$,

$$v_{j,t} = z_{j,t} \left(\frac{\ell_{j,t}}{1-\alpha_j} \right)^{1-\alpha_j} \left(\frac{k_{j,t}}{\alpha_j} \right)^{\alpha_j} = A_{j,t} \left(\frac{k_{j,t}}{\alpha_j} \right)^{\alpha_j},$$

- $A_{j,t}$ captures the joint behavior of TFP and Employment,

$$\Delta \ln A_{j,t} = \Delta \ln z_{j,t} + (1-\alpha_j) \Delta \ln \ell_{j,t}.$$

Sectoral Structural Change (II)

- Dynamics of TFP and labor, $x = z$ or L,

$$\Delta \ln x_{j,t} = \lambda^x_{j,\tau} \tau^x_{c,t} + \tau^x_{j,t} + \lambda^x_{j,\varepsilon} \varepsilon^x_{c,t} + \varepsilon^x_{j,t},$$

$$\tau^x_{c,t} = (1-\rho) g^x_c + \rho \tau^x_{c,t-1} + \eta^x_{c,t},$$

$$\tau^x_{j,t} = (1-\rho) g^x_j + \rho \tau^x_{j,t-1} + \eta^x_{j,t},$$

- Use estimated processes from unobserved components model.
- Trends in TFP and labor growth uncorrelated across sectors.
- We set ρ close to 1 in numerical simulations.

Balanced Growth and Sectoral Multipliers

- Expression for real GDP growth:

$$\Delta \ln V = s^{v} \left[I + \alpha_d \Omega' \underbrace{\left(I - \alpha_d \Gamma_d \Omega' - (I - \Gamma_d) \Phi' \right)^{-1} \Gamma_d}_{\Xi'} \right] \Delta \ln A$$

  with value-added shares, $s_i^v = p_i^v v_i / \sum_j p_j^v v_j$, and Generalized Leontief Inverse, Ξ'.

- Special cases of $\Delta \ln V = \mu \Delta \ln A$
  - Hulten (1978): $\alpha_i = 0$

$$\Delta \ln V = s^{v} \Delta \ln A$$

  - Identical independent industries: $\alpha_i = \alpha$, $\gamma_i = \gamma$, $\Phi = I$, and $\Omega = I$

$$\Delta \ln V = s^{v} \Delta \ln A / (1 - \alpha)$$

Sectoral Multipliers, $\mu = s^v \left(I + \alpha_d \Omega' \Xi' \right)$

Sector	s^v	$s^v \alpha_d \Omega' \Xi'$	μ
Agriculture	0.03	0.01	0.03
Mining	0.02	0.03	0.05
Utilities	0.02	0.01	0.03
Construction	0.05	0.12	0.17
Durable goods	0.13	0.28	0.42
Nondurable goods	0.09	0.03	0.13
Wholesale trade	0.07	0.08	0.15
Retail trade	0.08	0.02	0.11
Trans. & Ware.	0.04	0.03	0.07
Information	0.05	0.03	0.08
FIRE (x-Housing)	0.10	0.03	0.14
PBS	0.09	0.16	0.25
Educ. & Health	0.06	0.00	0.06
Arts, Ent., & Food svc.	0.04	0.01	0.04
Oth. serv. (x-Gov)	0.03	0.01	0.04
Housing	0.09	0.00	0.09

Sectoral Network Multipliers

- Network multipliers close the growth gap 1950-2016
  - 3.3% average GDP growth
  - 2.6% growth of GDP on the BGP of the 1-Sector Model (III), conditional on avg aggregate TFP and employment growth
  - 3.2% growth of GDP on the BGP of the 16-Sector model with IO and capital flow linkages,
    conditional on avg sectoral TFP and employment growth

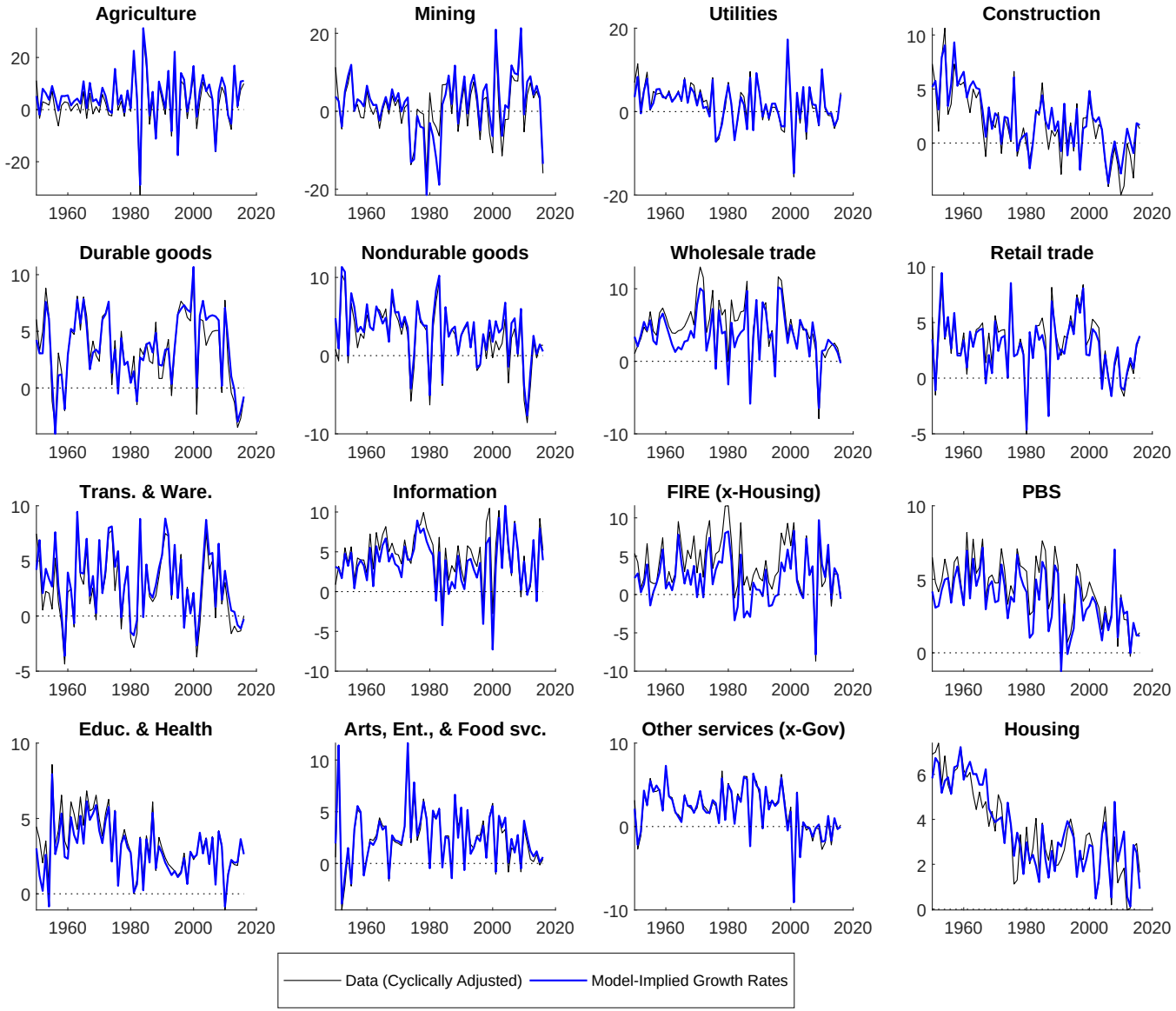
- The effects of structural change on GDP growth arise in part through composition effects, e.g.
  - aggregate TFP growth is $s^v \Delta \ln z$,
  - but the impact of TFP growth on aggregate GDP is $s^v \left(I + \alpha_d \Omega' \Xi'\right) \Delta \ln z$.

Dynamics off the BGP

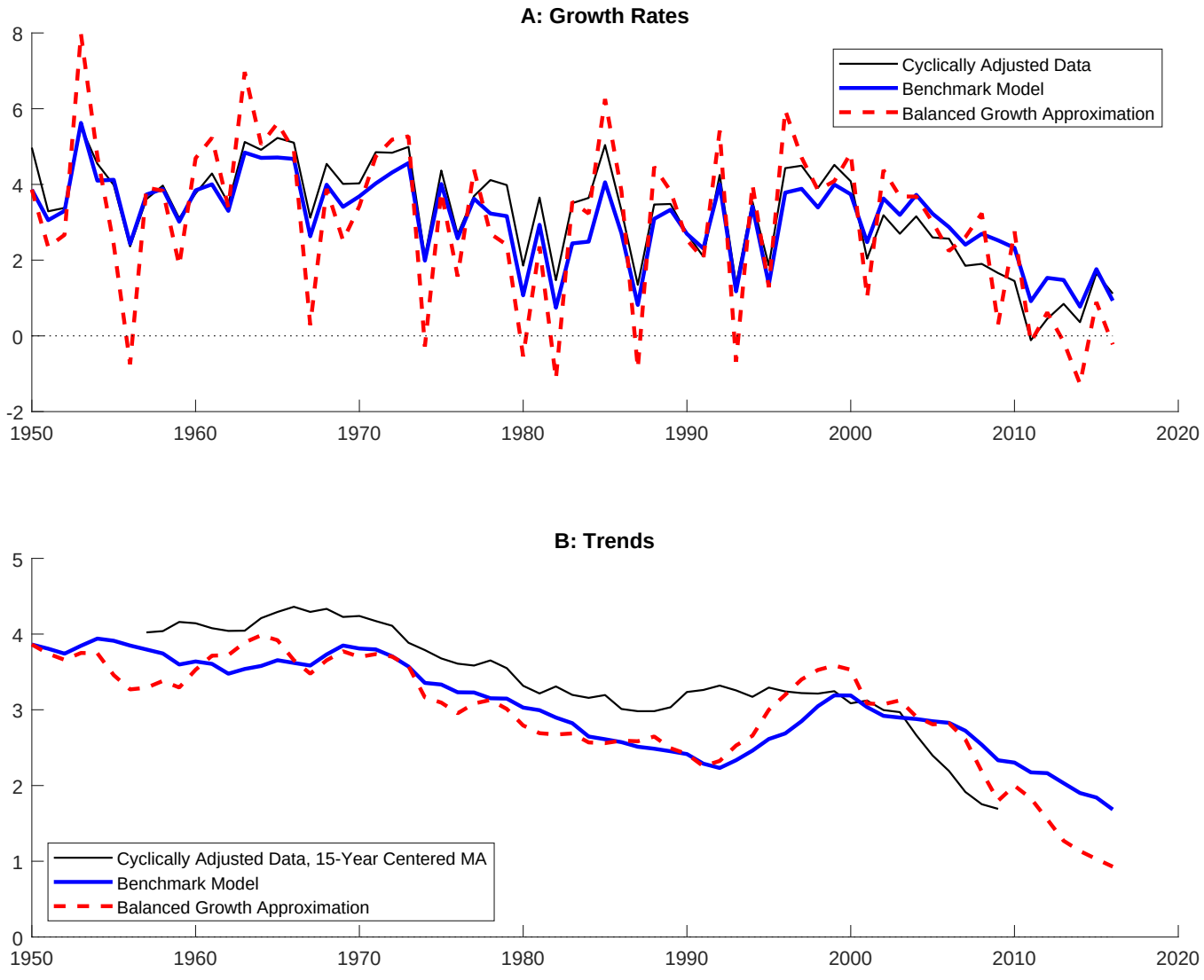
- The BGP equations ignore endogenous dynamics driven by capital accumulation. They miss dynamic terms that capture deviations from balanced growth.

- Now turn to full dynamics of model, then isolate effect of only the trend components.

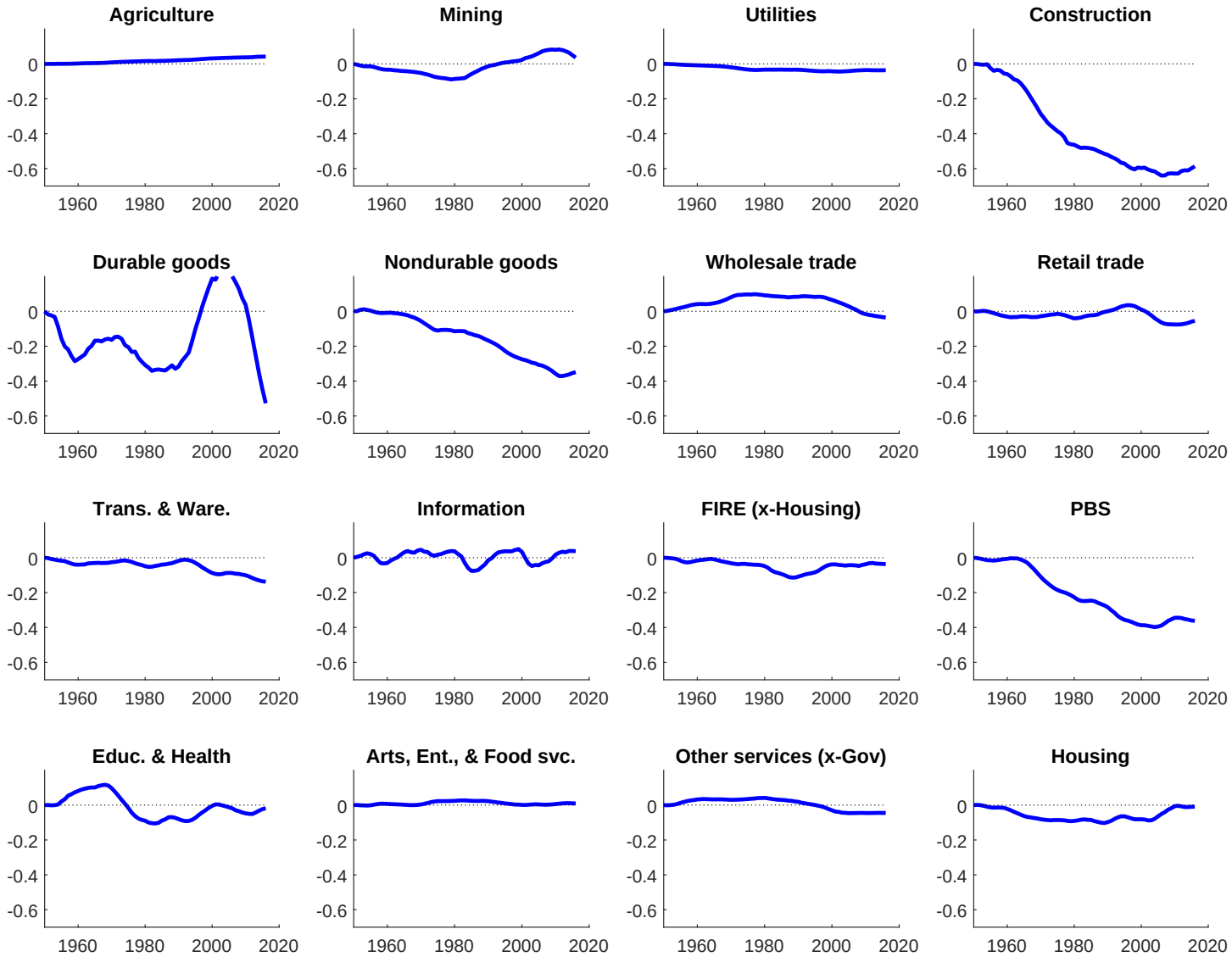
Sectoral Value Added Growth - Data and Model



Aggregate GDP Growth - Data and Model



Sectoral Contributions to Trend GDP Growth



Accounting vs Counterfactual

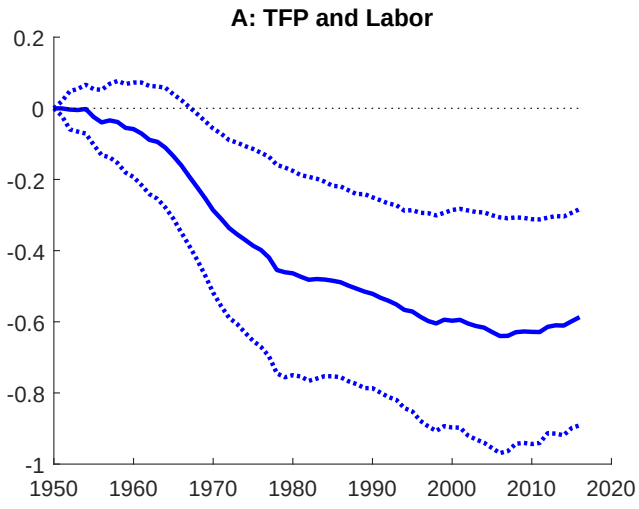
- Contribution of i-th sector to aggregate GDP growth in the absence of changes to all other sectors,

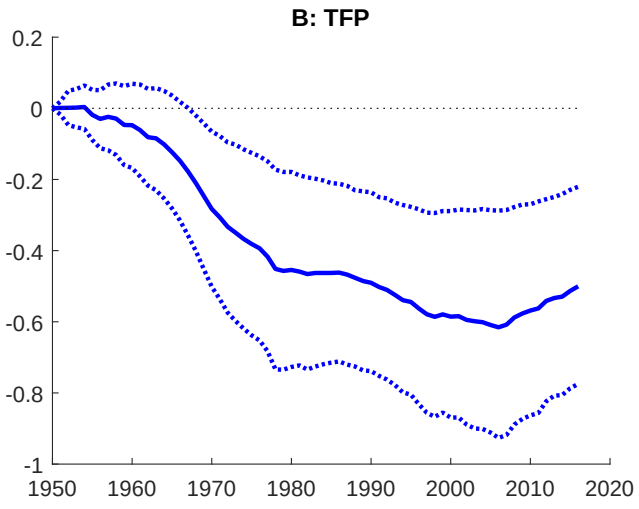
$$0 = \Delta \ln A_{j,t} = \Delta \ln z_{j,t} + \frac{\Delta \ln \ell_{j,t}}{1 - \alpha_j} \text{ for } j \neq i$$

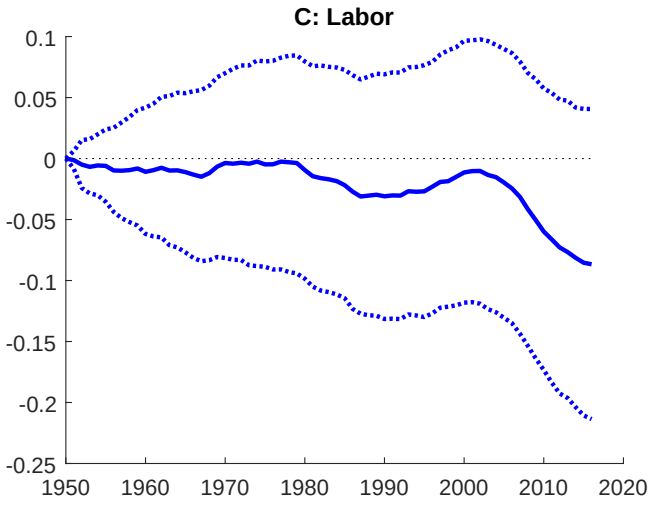
- Where does $\ell_{i,t}$ go to/come from?

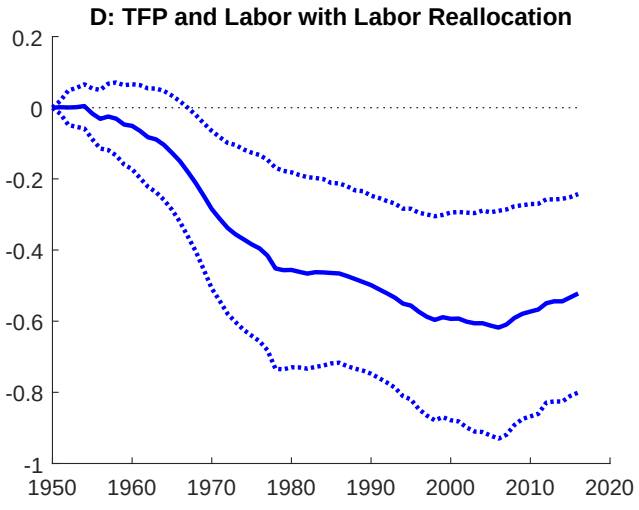
- Counterfactual with labor reallocation: allocate $\Delta \ln \ell_{i,t}$ to all other sectors according their employment shares such that sum of sectoral employment remains unchanged.
  - 3 sectors (CON, NDR, and PBS) make large negative contributions to trend GDP (mostly from TFP).
  - DUR makes large positive TFP and large negative employment contributions.

Construction Contributions to Trend GDP Growth

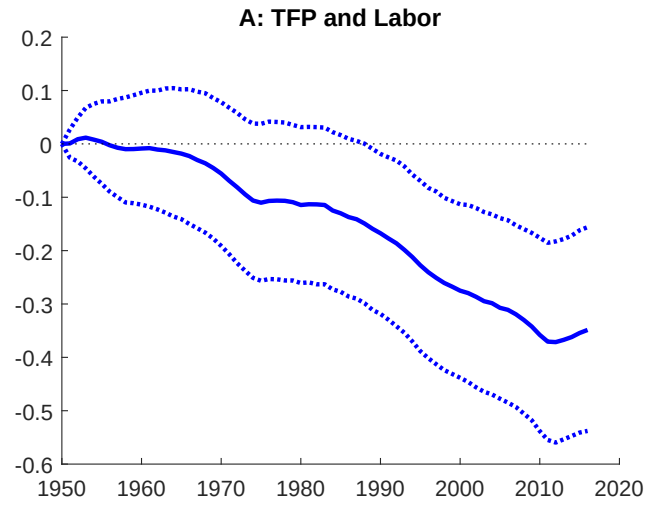


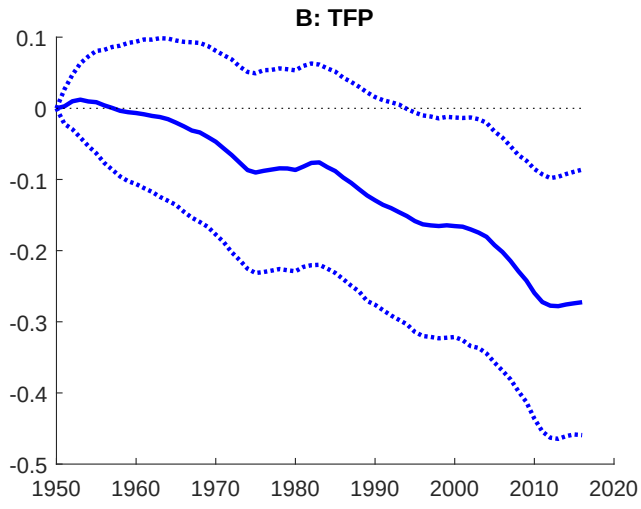


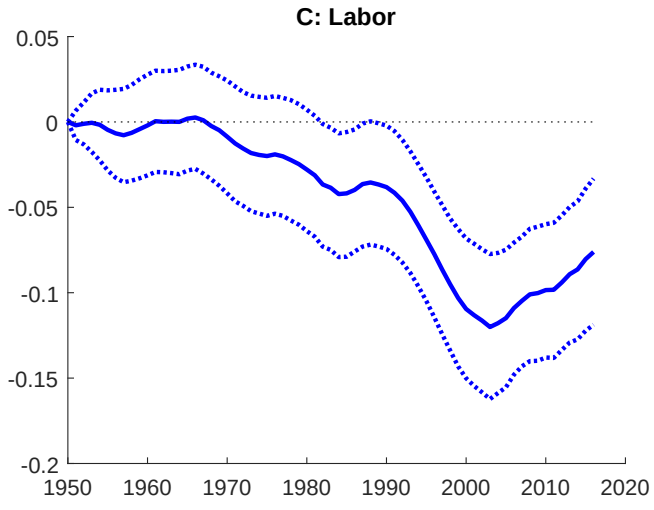


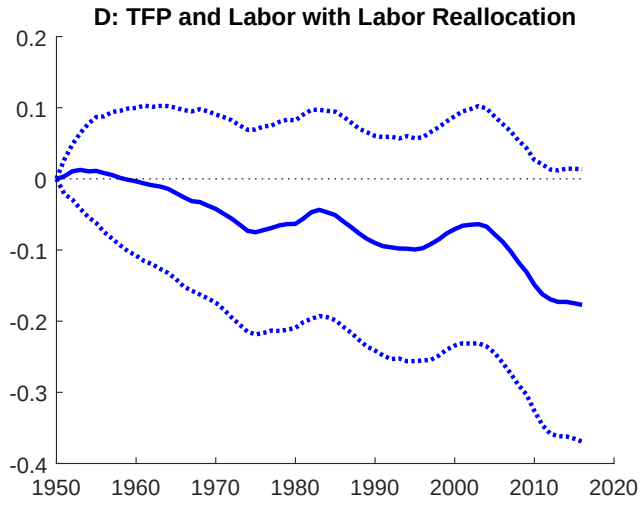


Nondurables Contributions to Trend GDP Growth

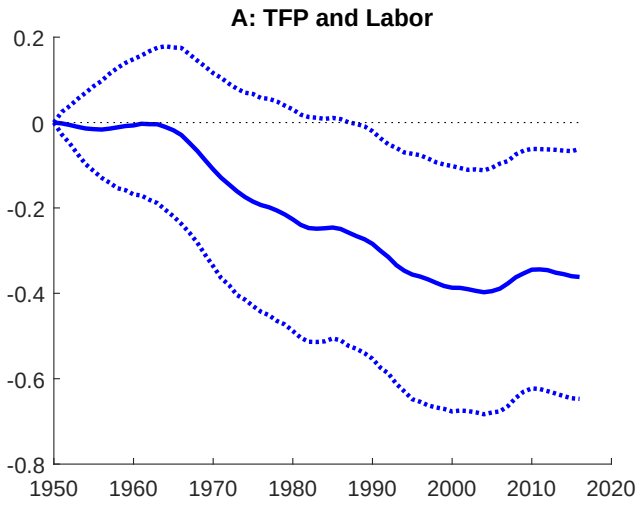


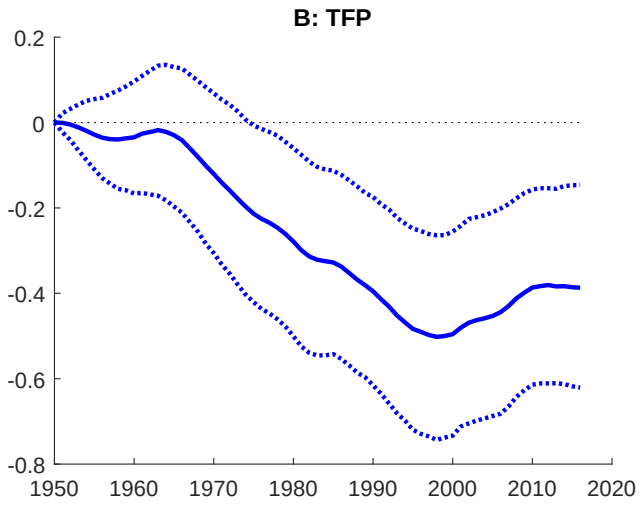


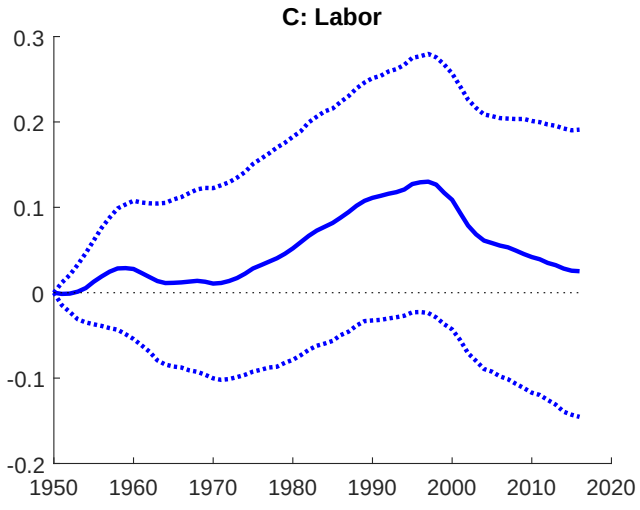


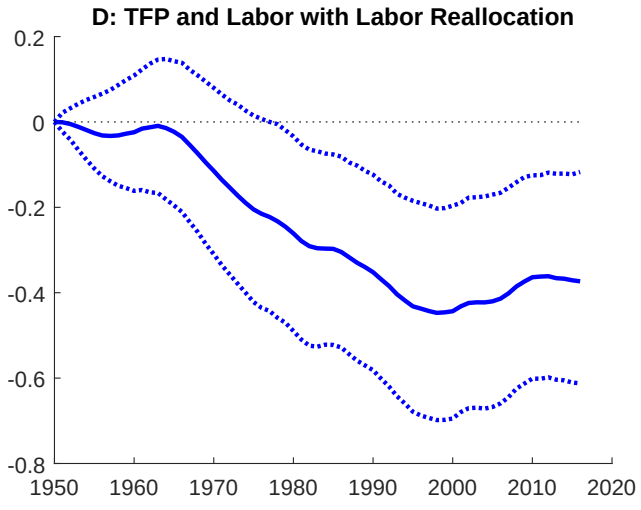


PBS Contributions to Trend GDP Growth

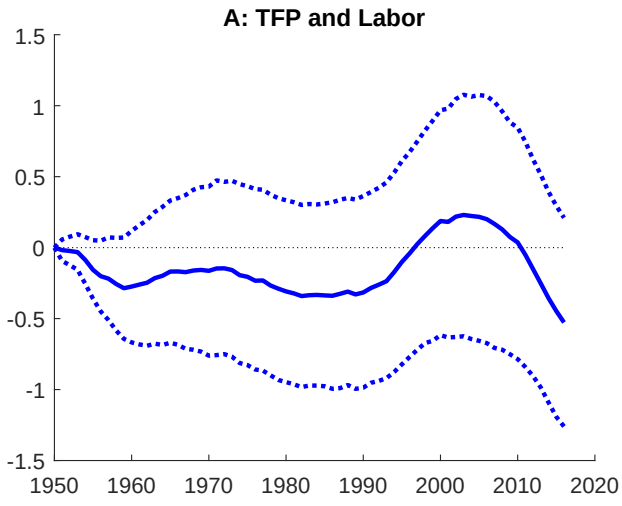


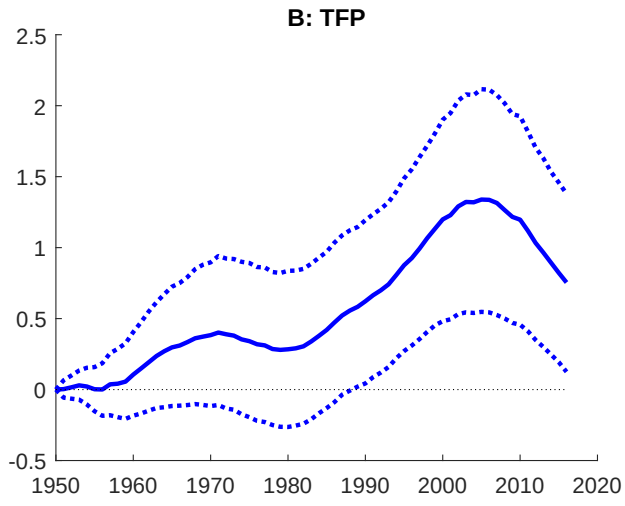


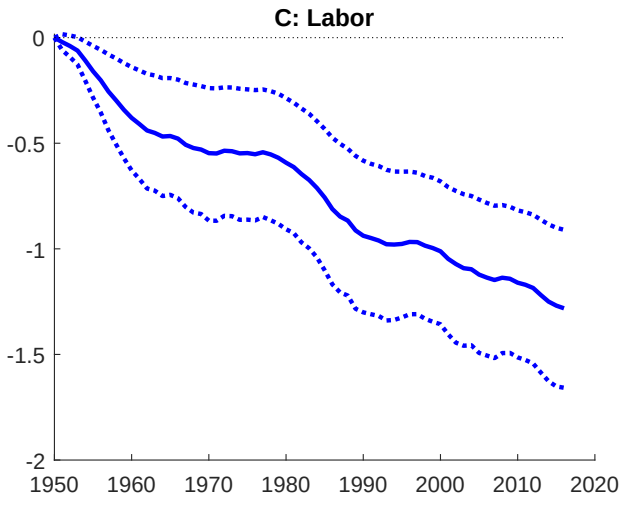


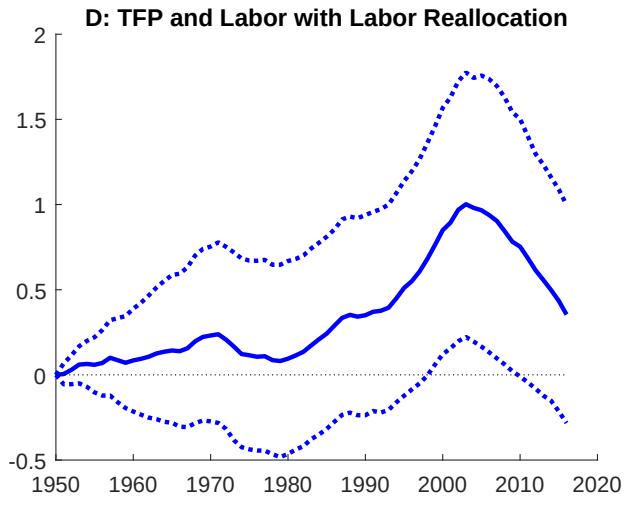


Durables Contributions to Trend GDP Growth

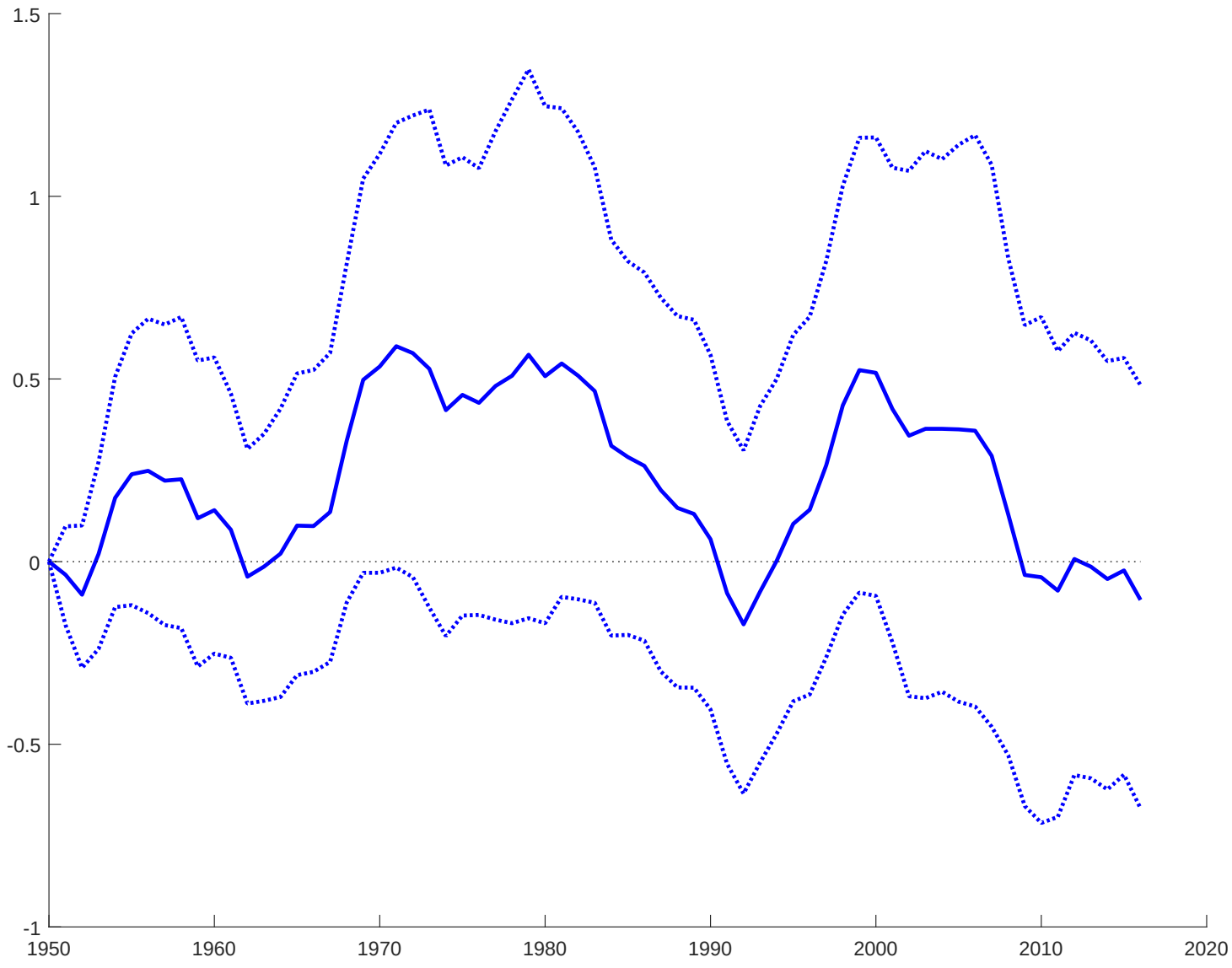




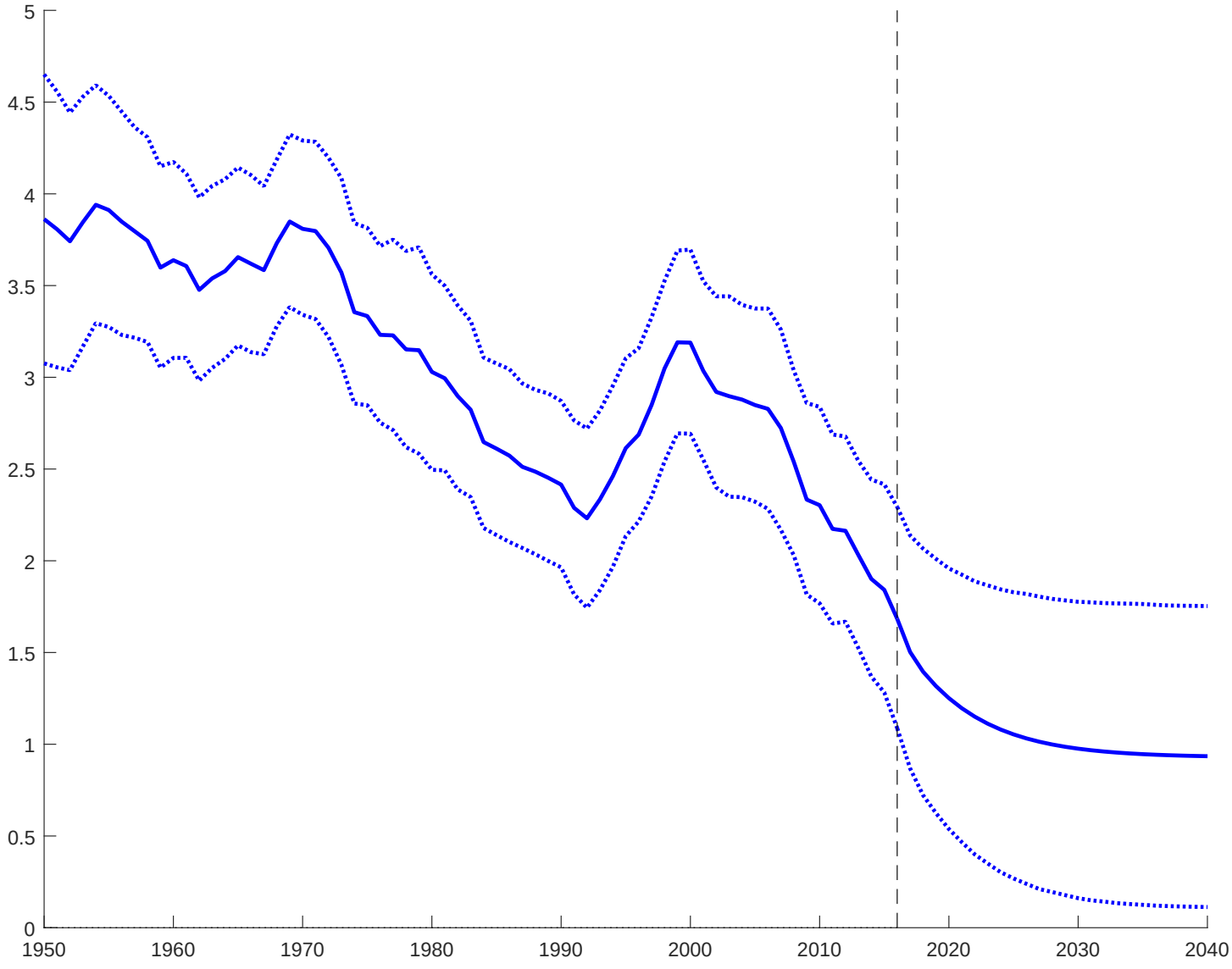




Common Trend Contribution to Trend GDP Growth



Projected GDP Trend Growth



Summary and Conclusions

- We estimate common and sector-specific trends in TFP and labor growth - find that sector-specific trends account for most of the decline in trend growth of aggregate TFP and labor.
- We incorporate the estimated trends in TFP and labor growth in a dynamic multi-sector model - find that linkages between sectors amplify the effects of sector-specific structural change on GDP growth.
- Some sectors are 3 times more important for GDP growth than their GDP-shares imply.
- We estimate a 2 ppt decline in trend GDP growth over the post-WW II period, most of it due to sector-specific factors.
- We project another 0.5 ppt decline in trend GDP growth over the next 10 years.