Vanishing Procyclicality of Productivity? Industry Evidence

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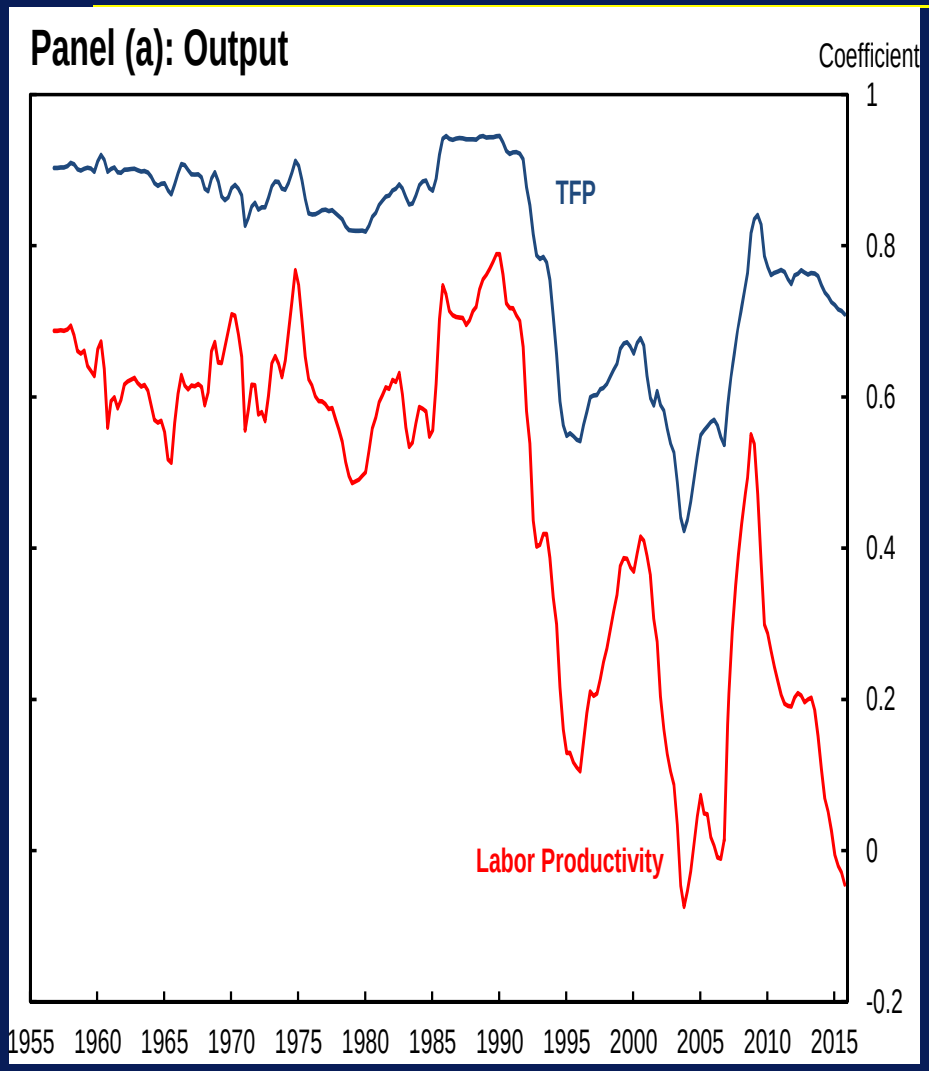
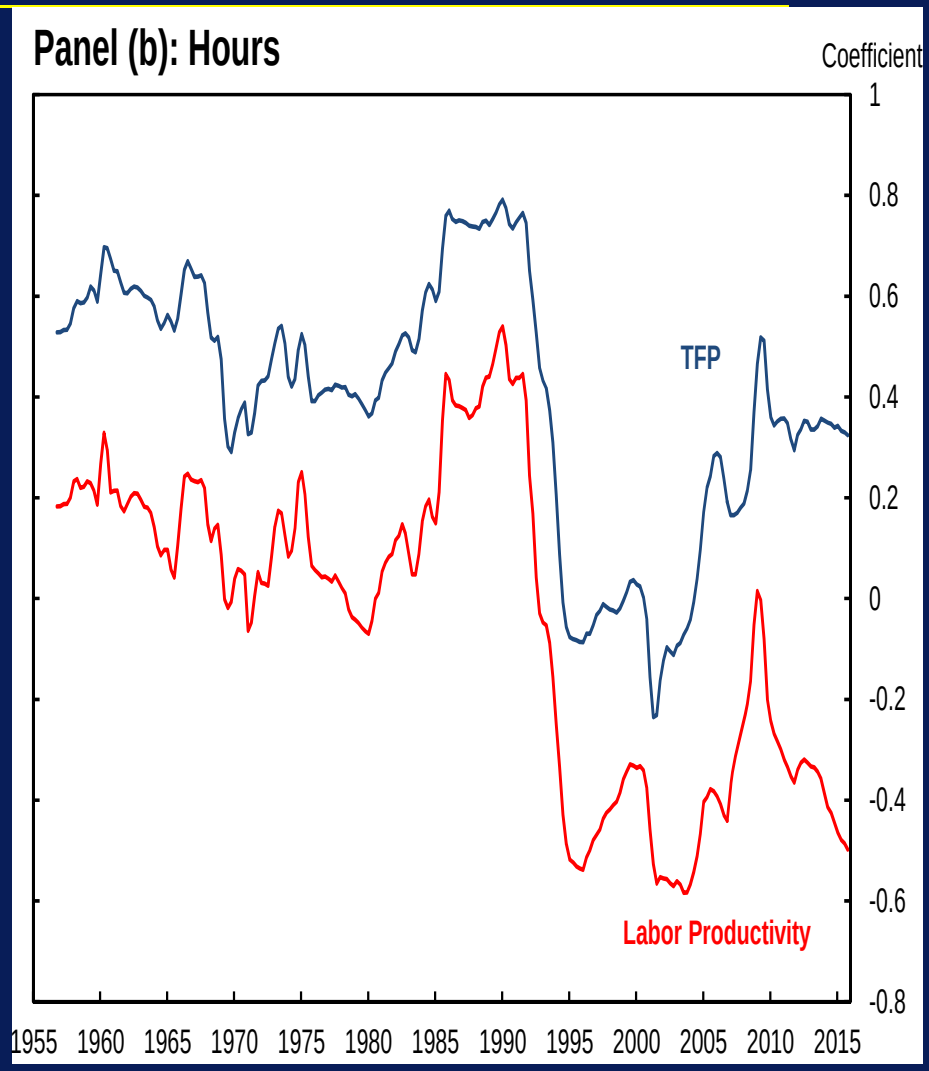
LP and TFP have become less correlated with output (VA) and inputs at the aggregate level





Note: BLS and Fernald (quarterly TFP) data as of 2015Q4, Fernald and Wang (2015)

Disaggregated data help identify the reason(s)

- Disaggregated (industry) data allow decomposition of TFP further into terms due to utilization and technical change to study respective contribution to the change in cyclicality
- Also allow one to test if relationships across variables predicted by a model is borne out in the cross-section
- Each proposed explanation is more relevant for some industries than others
  - E.g., union membership fallen more in some industries, presumably coinciding with more flexible labor market
- Can study if decline in aggregate correlation more due to within- vs. cross-industry forces

Search for explanation: decomposing productivity

- Growth rate of LP (da) and TFP (dt) defined:

$$\mathrm{d}a = \mathrm{d}v - \mathrm{d}h^T = \mathrm{d}t + s_K^V(\mathrm{d}k - \mathrm{d}l) + \mathrm{d}lq,$$

$$\mathrm{d}t = \mathrm{d}v - (s_L^V \mathrm{d}l + s_K^V \mathrm{d}k) \equiv \mathrm{d}v - \mathrm{d}x^V.$$

- Basu & Kimball (1997) model unobserved input variation leading to mismeasurement of TFP due to variable factor utilization, even assuming CRS

$$\mathrm{d}t_{it} = \mathrm{d}u_{it}^V + \mathrm{d}z_{it}^V.$$

- Here utilization refers to unobserved variation of inputs (e.g., labor effort, capital workweek). It is <u>not</u> the idea that elasticities of inputs may vary over time: Berndt-Fuss (1986), Hulten (1986), Morrison (1986)

TFP less correlated with inputs if volatility of technology shocks rises *relative* to vol. of TFP

$$\rightarrow \quad \rho\left(\mathrm{d}t, \mathrm{d}x^V\right) = \frac{\sigma(\mathrm{d}u^V)}{\sigma(\mathrm{d}t)}\rho\left(\mathrm{d}u^V, \mathrm{d}x^V\right) + \frac{\sigma(\mathrm{d}z^V)}{\sigma(\mathrm{d}t)}\rho\left(\mathrm{d}z^V, \mathrm{d}x^V\right).$$

- Assuming CRS, the change in TFP-input correlation:

$$\Delta\rho\left(\mathrm{d}t, \mathrm{d}x^V\right) \doteq \left\{\rho_0\left(\mathrm{d}u^V, \mathrm{d}x^V\right)\Delta\left[\frac{\sigma(\mathrm{d}u^V)}{\sigma(\mathrm{d}t)}\right] + \frac{\sigma_0(\mathrm{d}u^V)}{\sigma_0(\mathrm{d}t)}\Delta\rho\left(\mathrm{d}u^V, \mathrm{d}x^V\right)\right\}$$

$$+\left\{\rho_0\left(\mathrm{d}z^V, \mathrm{d}x^V\right)\Delta\left[\frac{\sigma(\mathrm{d}z^V)}{\sigma(\mathrm{d}t)}\right] + \frac{\sigma_0(\mathrm{d}z^V)}{\sigma_0(\mathrm{d}t)}\Delta\rho\left(\mathrm{d}z^V, \mathrm{d}x^V\right)\right\}.$$

$$\sigma^2\left(\mathrm{d}t\right) = \sigma^2\left(\mathrm{d}u^V\right) + \sigma^2\left(\mathrm{d}z^V\right) + 2\mathrm{cov}\left(\mathrm{d}u^V, \mathrm{d}z^V\right).$$

- Gali (1999) and BFK (2006) both find improvement in tech. to be contractionary → $\rho_0(\mathrm{d}z^V, \mathrm{d}x^V) < 0$

Estimate technology shocks from industry data

- Adjust TFP for utilization (tied to average hours per worker) to uncover true tech. term by IV estimation of gross output function (BFK, 2006), assuming CRS:

$$dy_{it} = dx_{it} + \beta_i dh_{it} + dz_{it}, \quad \text{with} \quad du_{it} = \beta_i dh_{it},$$

$$\text{VA-based } du_{it}^V \equiv du_{it}/(1 - s_{Mi}), \text{ and } dz_{it}^V \equiv dz_{it}/(1 - s_{Mi}).$$

$$\text{Aggregate } du^V = \sum_i w_i du_{it}^V, \text{ and } dz^V = \sum_i w_i dz_{it}^V.$$

Estimates of β:		**Manufacturing**		
(under CRS)	**Construction**	**Nondurable**	**Durable**	**Services (w/o FI)**
Detrended	1.971	5.248*	1.338***	1.255*
Avg. Hours	[2.274]	[2.373]	[0.309]	[0.691]
Observations	58	406	348	696
# of industries	1	7	6	12
Adjusted R^2	-1.501	-1.812	0.058	-0.382

TFP less correlated with inputs b/c σ(utilization) falls ➔ σ(tech) accounts for more of σ(TFP)

$$\Delta\rho\left(\mathrm{d}t,\mathrm{d}x^{V}\right)\doteq\left\{\rho_{0}\left(\mathrm{d}u^{V},\mathrm{d}x^{V}\right)\Delta\left[\frac{\sigma(\mathrm{d}u^{V})}{\sigma(\mathrm{d}t)}\right]+\frac{\sigma_{0}(\mathrm{d}u^{V})}{\sigma_{0}(\mathrm{d}t)}\Delta\rho\left(\mathrm{d}u^{V},\mathrm{d}x^{V}\right)\right\}$$

$$+\left\{\rho_{0}\left(\mathrm{d}z^{V},\mathrm{d}x^{V}\right)\Delta\left[\frac{\sigma(\mathrm{d}z^{V})}{\sigma(\mathrm{d}t)}\right]+\frac{\sigma_{0}(\mathrm{d}z^{V})}{\sigma_{0}(\mathrm{d}t)}\Delta\rho\left(\mathrm{d}z^{V},\mathrm{d}x^{V}\right)\right\}.$$

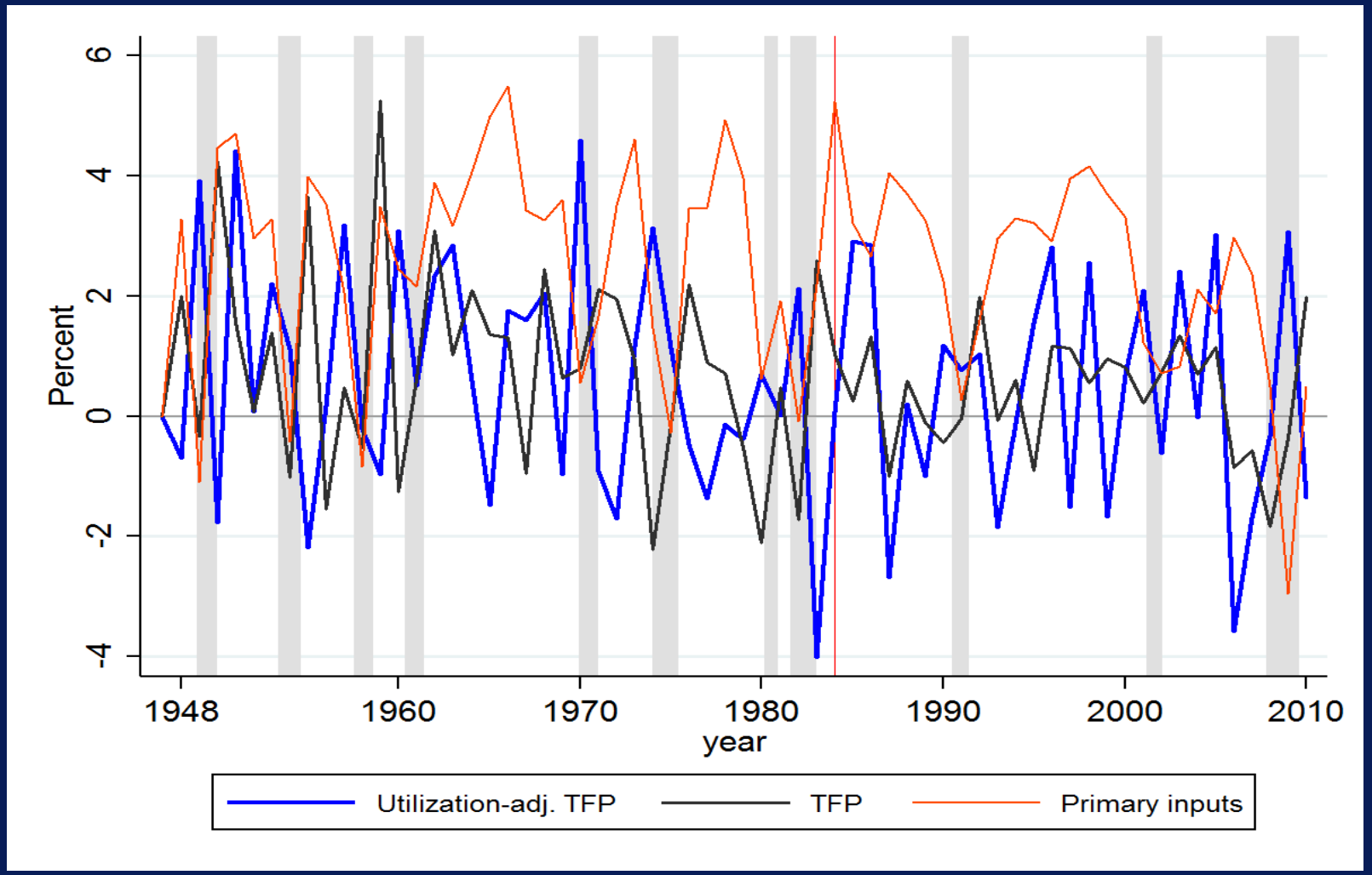
$\rho(\mathrm{d}t, \mathrm{d}x^V)$			Contribution of d*u* to $\rho(\mathrm{d}t, \mathrm{d}x^V)$			Contribution of d*z* to $\rho(\mathrm{d}t, \mathrm{d}x^V)$		
Pre-84	Post-84	Change	Pre-84	Post-84	Change	Pre-84	Post-84	Change
0.50	-0.11	-0.61	0.70	0.60	-0.10	-0.20	-0.65	-0.45

$\rho(\mathrm{d}u, \mathrm{d}x^V)$			$\rho(\mathrm{d}z, \mathrm{d}x^V)$		
Pre-84	Post-84	Change	Pre-84	Post-84	Change
0.40	0.29	-0.11	-0.18	-0.27	-0.09

$\sigma(\mathrm{d}t)$			$\sigma(\mathrm{d}u)$			$\sigma(\mathrm{d}z)$		
Pre-84	Post-84	Ratio	Pre-84	Post-84	Ratio	Pre-84	Post-84	Ratio
1.78	0.80	0.45	3.09	1.67	0.54	1.97	1.93	0.98

Note: total of 27 private industries except for agriculture and mining.
Source: Industry dataset by Ho, Jorgenson and Samuels, www.worldklems.net

Utilization-adjusted TFP no less cyclical, nor less volatile



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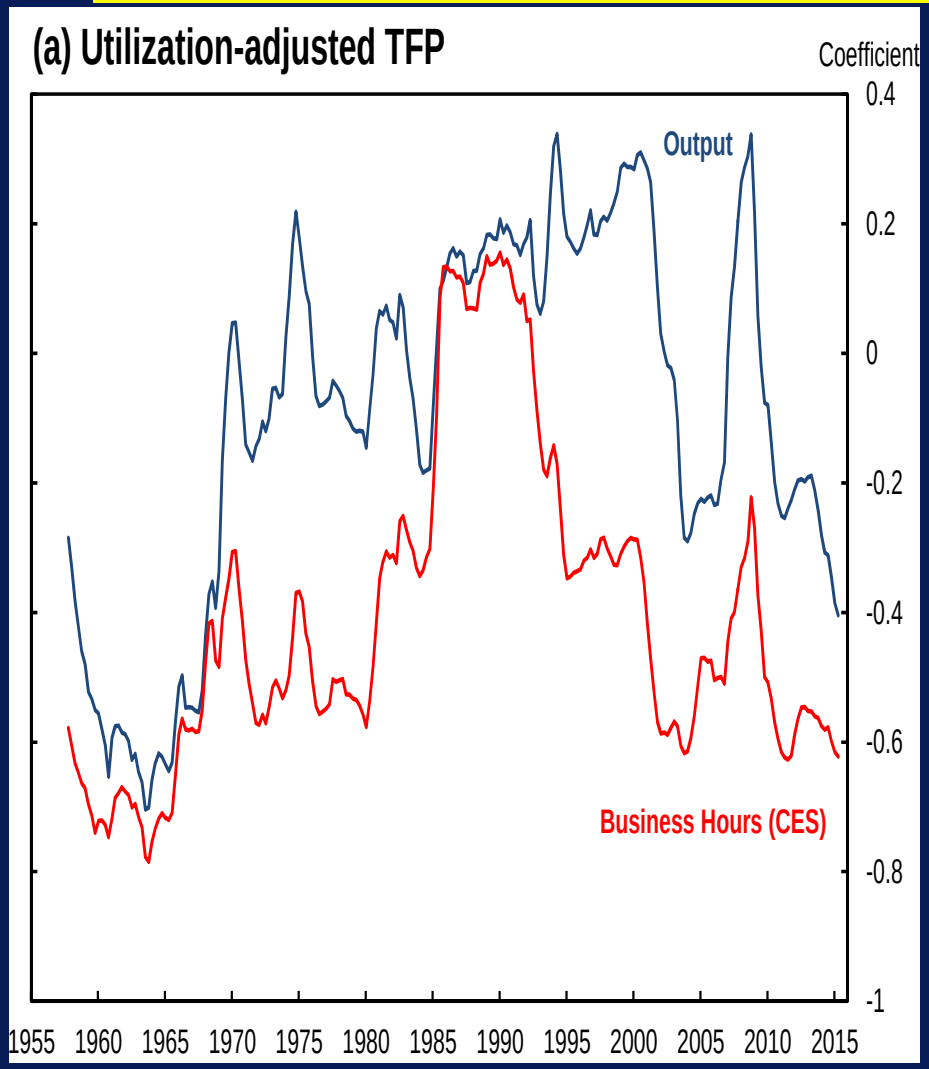
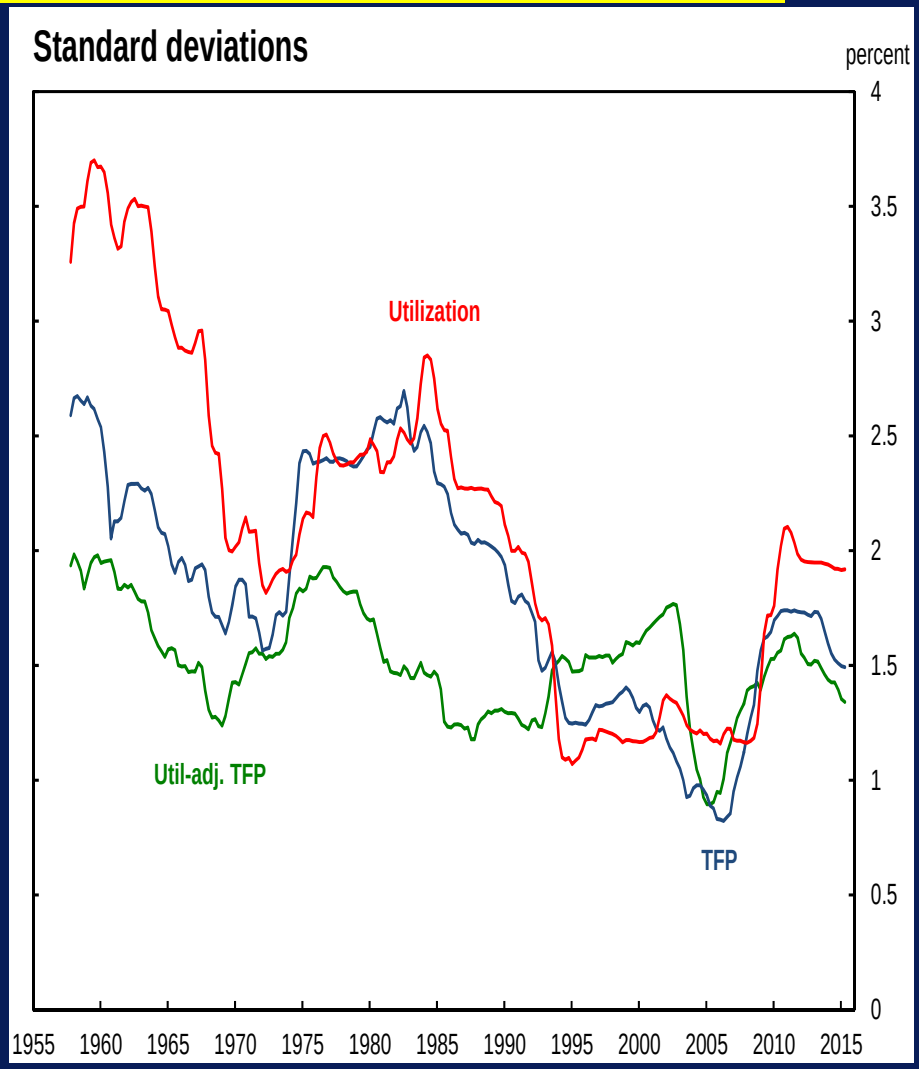




Note: BLS and Fernald (quarterly TFP) data as of 2015Q4, Fernald and Wang (2015)

Utilization still responds negatively to same-year tech. improvement after mid-1980s, albeit less so

RHS	VA	Total hours	Employment	Hrs/Worker	Utilization	TFP
dz	-0.426**	-0.390**	-0.216	-0.180***	**-1.215*** **	**-0.227***
	[0.206]	[0.155]	[0.141]	[0.0288]	**[0.122]**	**[0.119]**
$dz*D_{post84}$	0.516*	0.132	0.138	0.00268	**0.498*** **	**0.487*** **
	[0.264]	[0.236]	[0.209]	[0.0369]	**[0.144]**	**[0.144]**
dz(-1)	-0.143	-0.583***	-0.561***	-0.0309	**0.169**	**0.166**
	[0.233]	[0.175]	[0.159]	[0.0325]	**[0.138]**	**[0.135]**
$dz(-1)*D_{post84}$	0.177	0.387	0.382*	0.0138	**-0.0204**	**-0.000355**
	[0.291]	[0.257]	[0.228]	[0.0407]	**[0.160]**	**[0.160]**
dz(-2)	0.859***	0.396**	0.281*	0.113***	**0.540*** **	**0.577*** **
	[0.231]	[0.173]	[0.158]	[0.0322]	**[0.137]**	**[0.134]**
$dz(-2)*D_{post84}$	-0.589**	-0.328	-0.265	-0.0637	**-0.306***	**-0.367****
	[0.299]	[0.267]	[0.237]	[0.0417]	**[0.162]**	**[0.163]**
dz(-3)	0.480**	0.386**	0.334**	0.0615*	**0.159**	**0.133**
	[0.228]	[0.171]	[0.156]	[0.0318]	**[0.135]**	**[0.132]**
$dz(-3)*D_{post84}$	-0.307	-0.260	-0.235	-0.0282	**-0.0672**	**-0.0592**
	[0.299]	[0.269]	[0.239]	[0.0418]	**[0.162]**	**[0.162]**
dz(-4)	0.357*	0.288*	0.299**	0.00762	**0.0701**	**0.0770**
	[0.215]	[0.161]	[0.147]	[0.0300]	**[0.127]**	**[0.125]**
$dz(-4)*D_{post84}$	-0.193	-0.202	-0.241	0.0302	**0.0688**	**0.0493**
	[0.276]	[0.247]	[0.219]	[0.0386]	**[0.150]**	**[0.151]**
$\sigma*D_{post84}$	-0.903***	-0.266	-0.296	-0.125***	**-0.703*** **	**-0.640*** **
	[0.323]	[0.280]	[0.250]	[0.0452]	**[0.179]**	**[0.178]**
σ(resid.)	2.168***	1.627***	1.481***	0.303***	**1.285*** **	**1.257*** **
	[0.267]	[0.200]	[0.182]	[0.0372]	**[0.158]**	**[0.155]**
Observations	57	57	57	57	**57**	**57**
Chi-squared	27.96	38.95	33.52	167.3	**303.4**	**42.56**

Consistent with finding that tech. shocks seem to have become more persistent, or better policy

LHS: d*z*	1950-2007	1948-2010
d*z*(-1)	0.108	0.104
	[0.194]	[0.175]
d*z*(-1)*D_{post84}	0.364**	0.350**
	[0.152]	[0.154]
D_{post73}	-0.702***	-0.722***
	[0.171]	[0.157]
Constant	0.911***	0.928***
	[0.212]	[0.191]
Observations	58	63
Chi-squared	184.6	249.9

Note: Alternative specifications (e.g., in log levels, accounting for generated regressor problem) also mostly indicate an increase in the AR(1) coefficient of technology shocks

- Since inputs contract within 1st year in response to better tech. but then expand, more persistent tech. changes ➔ cut less of costlier-to-adjust inputs (# of workers) & more of other inputs (e.g. hours/worker) upon impact
- Also consistent with better monetary policy

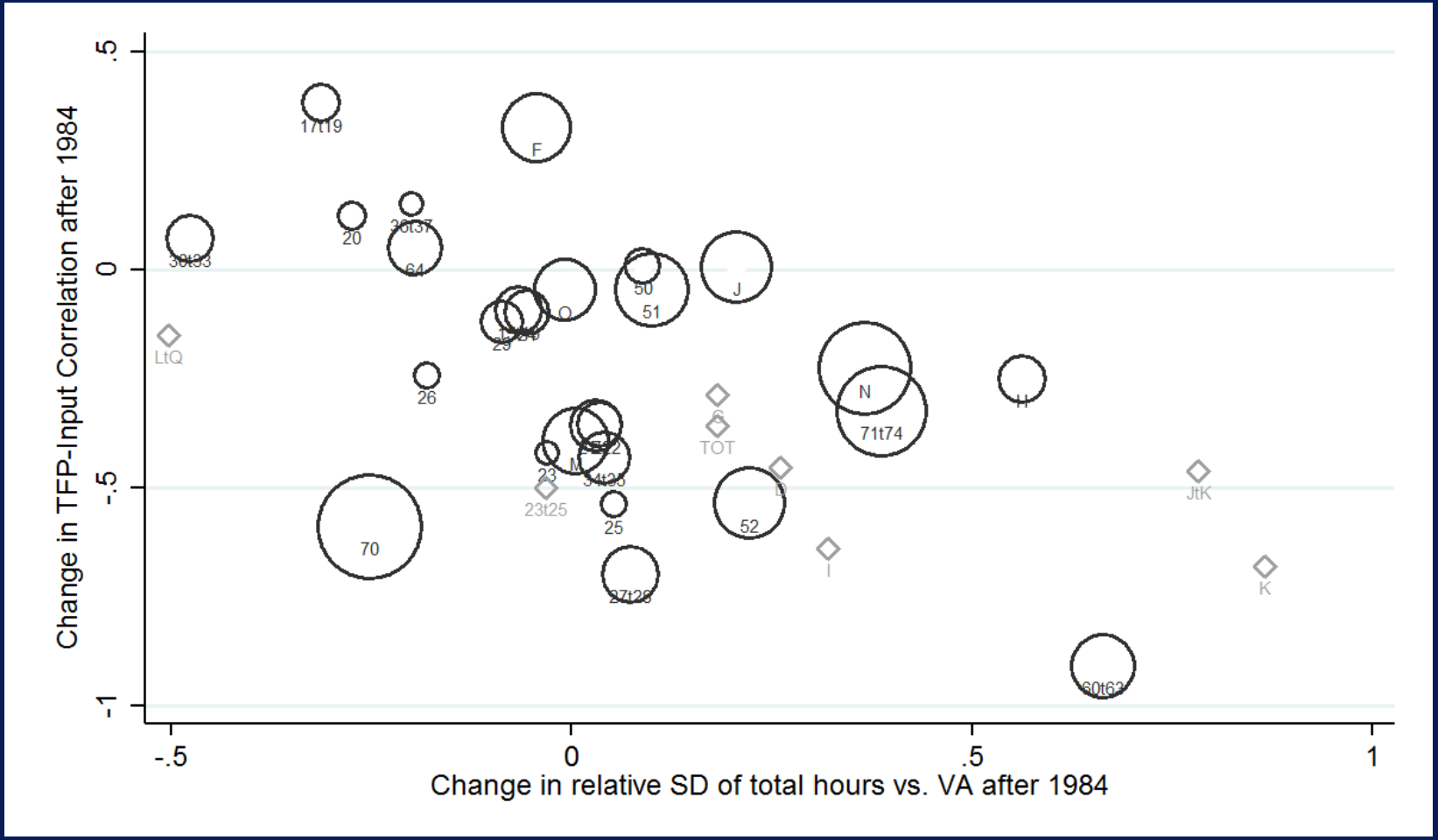
Proposed explanation: less measurement errors in labor inputs due to lower adjustment cost

- Gali & van Rens (2010): Suppose lower adjustment costs of employment. Then inputs will be adjusted more via the (observed) extensive than (unobserved) intensive margin

➔ *Measured* TFP becomes less procyclical

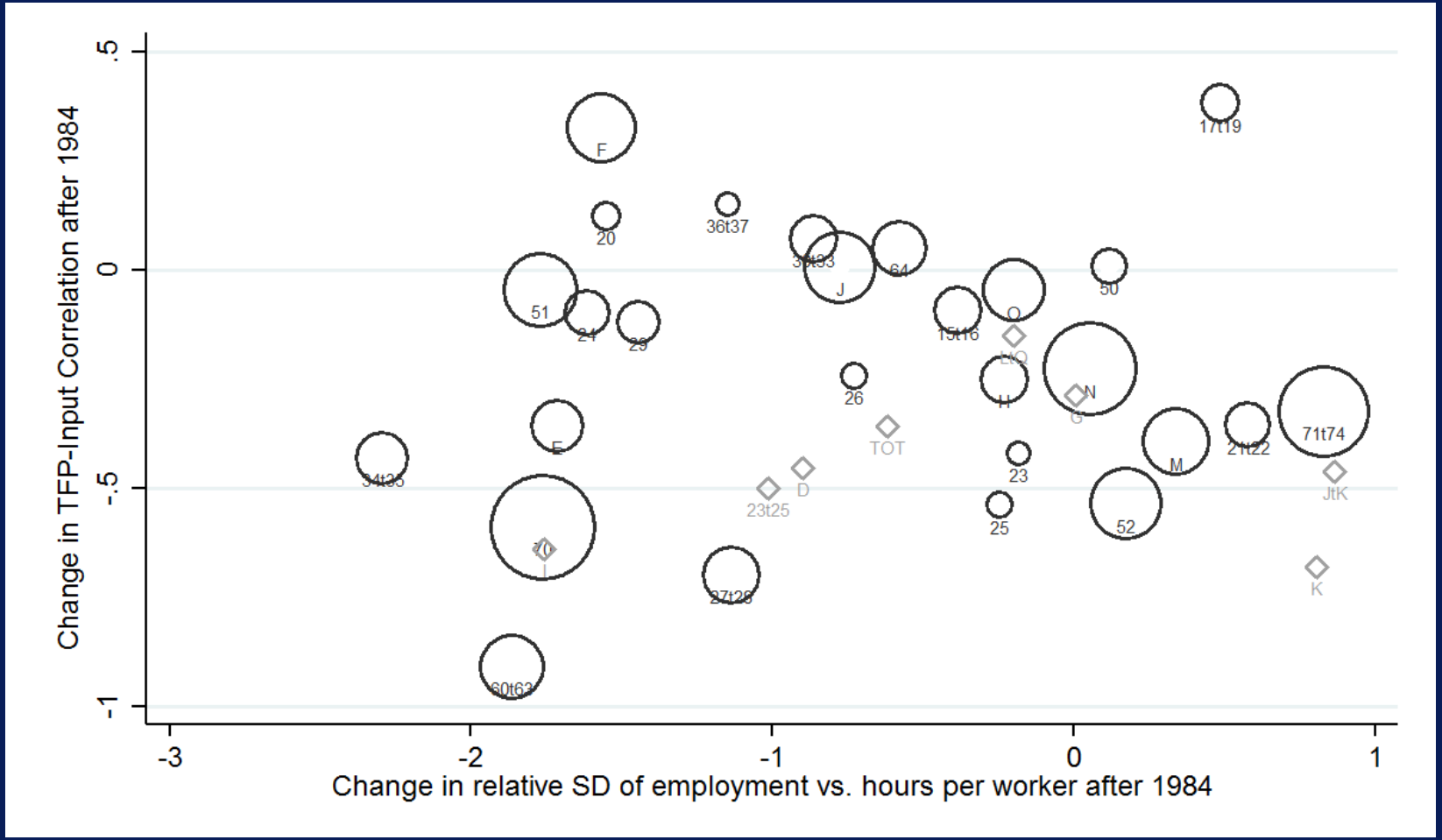
- Testable implication 1: Industries where TFP cyclicality falls more should show volatility of employment or total hours rise more vis-à-vis volatility of VA
- Testable implication 2: Across industries, the volatility of employment should increase more relative to the volatility of average hours per worker for industries where TFP cyclicality falls more

Less procyclical TFP related to increase in input-to-output volatility ratio across industries



Note: 27 private industries except for agriculture and mining depicted in circles, with circle size proportional to sample average VA share; sectors & total economy in grey diamonds.
Source: Industry dataset by Ho, Jorgenson and Samuels, www.worldklems.net

But less procyclical TFP not due to more flexible adjustment of extensive vs. intensive margin



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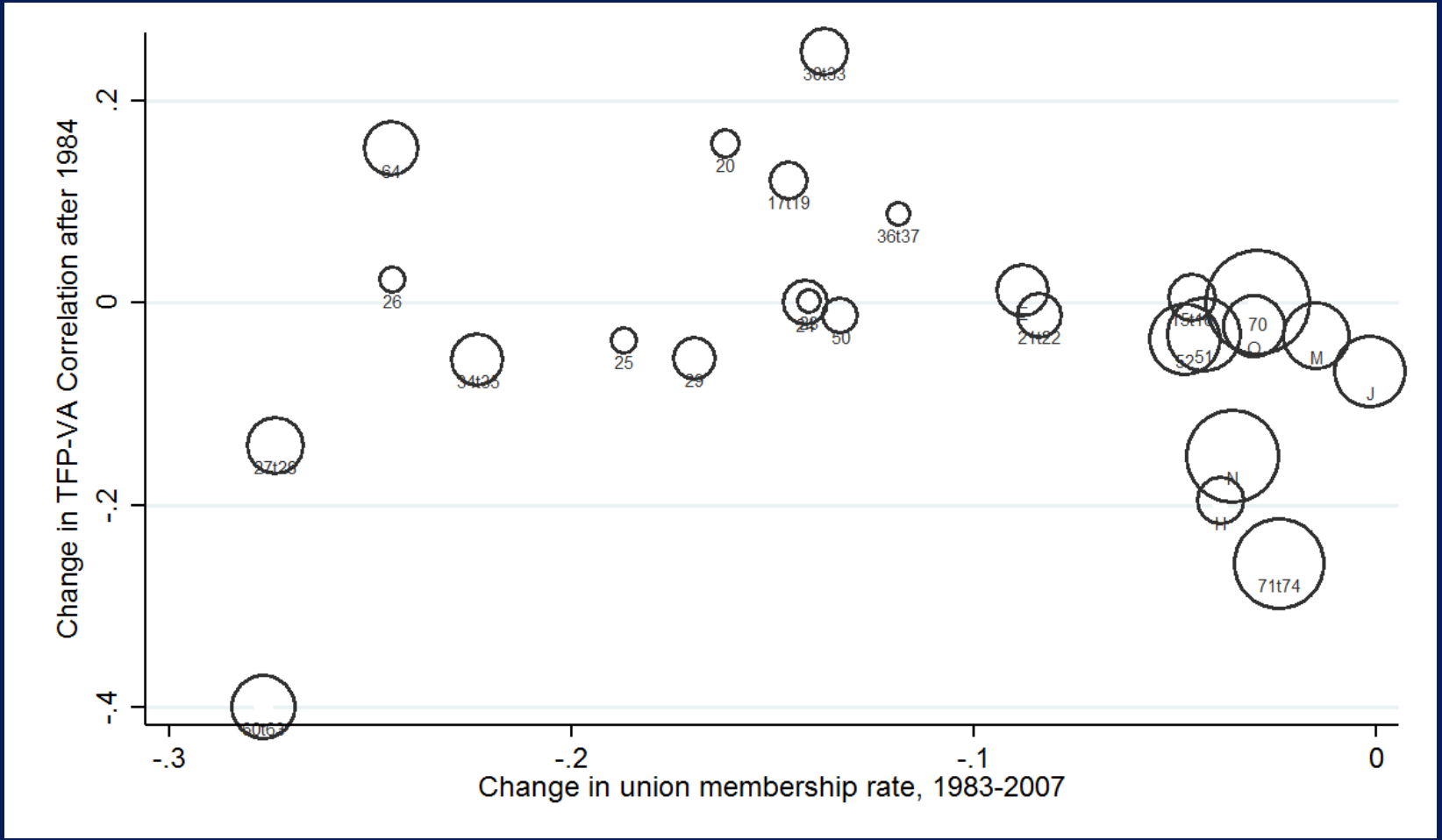
Nor is less procyclical TFP clearly related to declines in union membership



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Plausible story: less procyclical TFP due to lower adj. cost in general, or diff. properties of shocks

- Cross-industry pattern consistent with overall more flexible/variable inputs vis-à-vis output since mid-80s
- But inconsistent with the prediction that extensive margin (employment) now more flexible than intensive margin (hours/worker). May not be necessary for some shocks…
  - Employment reacts less negatively (than hours/worker) to same-year tech. improvement after 1984, possibly b/c of more persistent tech. shocks, or better monetary policy.
  - Decline in unconditional relative volatility of employment may also be due to less persistent demand shocks (Ramey and Vine, 2006)
- No need for intangible capital story of McGrattan and Prescott (2007, 2010)

Concluding remarks

- Aggregate LP and TFP has become less procyclical since mid-80s …
- … largely because technical change has come to account for a greater share of the TFP-input correlation, and …
- … technical change comoves negatively with inputs (i.e., better tech. causes input to contract on impact)
- Cross-industry pattern is consistent with lower cost of adjusting employment as well as hours/worker
- But also consistent with changes in other aspects of the economic structure: changing industry composition, better monetary policy, different persistence of technology or demand shocks