Why Hours Worked Decline Less after Technology Shocks?

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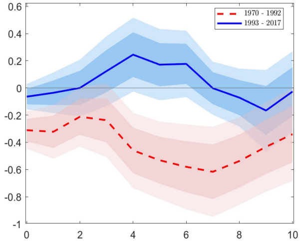
Motivation

- Focus on the effects of permanent technology improvements on hours in (17) OECD countries
- **Investigate whether the effects of technology shocks on hours vary across time (1970-2017)**
- Fig. (left panel) shows the response of L to technology shock (by 1% in the long-run) over two sub-periods: 70-92 (red) vs. 93-17 (blue)
- L_t falls dramatically over 70-92 while it remains unresponsive over 93-17.



Objective

- Question: What is the factor behind the vanishing decline in hours after a technology shock?
- We put forward the increasing importance of asymmetric technology shocks in driving permanent technology improvement
- Our estimates reveal that the share of the FEV of agg. technological change explained by asym. tech. shocks is 8% in the pre-1992 period and 44% in the post-1992 period
- To test our hypothesis and provide a structural interpretation of the mechanism
- we develop a model with two key elements including international openness and the multi-sector dimension
  - International openness generates a strong negative link between technology and hours worked
  - Second element: multi-sector dimension produces a strong positive link between technology and hours worked

Main Contribution vs. Existing Literature

- The vanishing decline in hours following a technology shock we document for OECD countries
- has been well documented for the U.S. by the existing literature suggests different explanations
  - Galí and Gambetti 2009 put forward more pro-cyclical mon. pol. pro-cyclical $\Rightarrow$ $L(0)$ falls less or increases (Dotsey 1999).
  - Barnichon 2010, Galí and Van Rens 2021 put forward the decline in hiring costs which lead firms to adjust employment
  - Nucci and Riggi 2013 put forward an increase in performance-related pay schemes from mid-1980s $\Rightarrow$ further increase W
  - Cantore et al. 2017 put forward greater substitutability btw K and L
- Our evidence show that none of these explanations can rationalize the vanishing decline in hours in OECD countries
- In contrast, we stress the importance of open economy dimension (lowers L) and also the multi-sector aspect by decomposing TC into a sym. and asym. component:
  - $L(0)$ decline after agg. tech shocks because they are primarily driven by sym. tech. shocks
  - BUT the decline in $L(0)$ shrinks because agg. tech shocks are increasingly driven by asym. tech. shocks

Decomposition of TC into Sym. vs. Asym Components

- Objective: VAR decomposition of sym. and asym. tech. shocks. A hat means % deviation from initial SS.
- Starting point of is the sectoral decomposition of agg. TC measured by deviation of utilization-adjusted-aggregate-TFP relative to the initial SS $\hat{Z}_t^A$:

$$\hat{Z}_t^A = \nu^{Y,H} \hat{Z}_t^H + \left(1 - \nu^{Y,H}\right) \hat{Z}_t^N, \tag{1}$$

where $\nu^{Y,H}$ = value added share of tradables

- We rearrange the sectoral decomposition of $\hat{Z}_t^A$ so that sym. and asym. components show up:

$$\begin{aligned} \hat{Z}^A(t) &= \hat{Z}^N(t) + \nu^{Y,H}\left(\hat{Z}^H(t) - \hat{Z}^N(t)\right), \\ &= \hat{Z}^{A,SYM} + \nu^{Y,H}\left(\hat{Z}^H(t) - \hat{Z}^N(t)\right). \end{aligned} \tag{2}$$

- SYM component: When $\hat{Z}^H(t) = \hat{Z}^N(t) \Rightarrow$ last term drops so that $\hat{Z}^A(t) = \hat{Z}^{A,SYM}(t)$
- ASYM component: The second term on the RHS $\nu^{Y,H}\left(\hat{Z}^H(t) - \hat{Z}^N(t)\right)$ measures the excess of $\hat{Z}^H(t)$ over $\hat{Z}^N(t)$

Sym. vs. Asym Tech Shocks: VAR Identification

- To conduct a VAR-based decomposition of technology shocks into symmetric and asymmetric tech shocks
- we estimate a reduced form VAR model in panel format on annual data with country fixed effects and time dummies; its structural MA representation is shown below (we assume $\eta_{it} = A_0 \varepsilon^Z_{it}$):

$$\hat{X}_{it} = B(L) A_0 \varepsilon^Z_{it}, \tag{3}$$

- We estimate 2 versions of the VAR model.
- In the 1st version, the VAR model includes $\hat{Z}^A_{it}$, $\hat{Y}_{R,it}$, $\hat{L}_{it}$, $\hat{W}_{C,it}$ $\Rightarrow$ Like Gali (1999) $\Rightarrow$ impose long-run restrictions to identify agg. tech. shocks ε^Z_{it}
- In the 2nd version, we augment the 1st version with $\hat{Z}^H_{it} - \hat{Z}^N_{it}$ ordered 1st in the VAR model and we impose long-run restrictions such that both sym and asym tech shocks increase permanently Z^A_{it} while only asym tech shocks increase permanently Z^H_{it}/Z^N_{it} $\Rightarrow$ $A(1) = B(1)A_0$ lower triangular (i.e., $A_{12} = 0$):

$$\begin{bmatrix} \hat{Z}^H_{it} - \hat{Z}^N_{it} \\ \hat{Z}^A_{it} \end{bmatrix} = \begin{bmatrix} A_{11} & 0 \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} \epsilon^{A,ASYM}_{it} \\ \epsilon^{A,SYM}_{it} \end{bmatrix} \tag{4}$$

- Second step. Estimate the dynamic effects of ε^Z_{it} by using Jordà's (2005) projection method:

$$x^j_{i,t+h} = \alpha^j_{i,h} + \alpha^j_{t,h} + \psi^j_h (L) \, z_{i,t-1} + \gamma^j_h \epsilon^Z_{i,t} + \eta^j_{i,t+h}.$$

Dataset

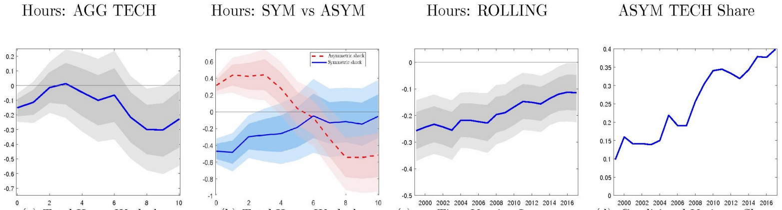
- Our sample consists of a panel of **17 OECD countries over 1970-2017**; the dataset covers 11 industries (KLEMS, ISIC rev.3);
- classified as H and N
  - 5 Traded industries: Agriculture; Mining and Quarrying; Total Manufacturing; Transport & Communication; Financial Intermediation.
  - 6 Non Traded industries: Electricity, Gas & Water Supply; Construct.; Wholesale & Retail Trade; Hotels & Rest.; Real Estate, Renting & Business Activities; Community Social & Personal Serv. (Public administration & Defense, Education, Health, Other)
  - **Trade Openness Industry** $k = \frac{\text{Exp} + \text{Imp}}{\text{Output}}$. Cutoff: 20%.
  -

Traded	Agri.	Mining	Manufact.	Trans & Comm.	Finance	
	0.39	3.67	0.88	0.33	0.20	
Non-Traded	Energy	Construct.	Wh. Trade	Hot. & Res.	Real est.	Public
	0.11	0.02	0.12	0.14	0.20	0.04

- $Y^j = \sum_{\in j} Y^{k,j}$, $L^j = \sum_{k \in j} L^{k,j}$,
- $K^j = \omega^{Y,j} K$ where K is computed by adopting the perpetual inventory approach and $\omega^{Y,j}$ = VA share of sector j at current prices.
- TFP^j = Solow residual; $\hat{Z}^j = \hat{\text{TFP}}^j - \left(1 - s_L^j\right) \hat{u}^{K,j}$ = capital-utilization adjusted TFP where time series of $u^{K,j}$ are constructed by adapting the method proposed by Imbs (1999)
- alternatively, we have constructed measures of technology based on Basu (1996) which has the advantage of controlling for unobserved changes in both cap. ut. and intensity of work effort

Effects on Hours of a Technology Shock

- Panel (a): Response of Hours to tech shock. Blue line: point estimate. Shaded areas: 68% (dark) and 90% (light) conf. bounds.
- Panel (b): Response of Hours to Sym (blue) vs. Asym (dashed red) Tech shocks.
- panel (c): plot the impact response of Hours to a Tech Shock over rolling windows ($T = 30$ years): 70-99, 71-00, ...88-17
- $\Rightarrow \hat{L}(0) = -0.26\%$ over 70-00 and $\hat{L}(0) = -0.11\%$ over 87-17
- in line with our hyp: panel (d) shows that the FEV share of tech shocks attributed to asym tech change has dramatically increased from 10% to 40%



(a) Total Hours Worked

(b) Total Hours Worked

(c) Time-Varying Impact Response of Hours Worked

(d) Conditional Variance Share of Asymmetric Technology Shocks

Framework: Frictions into Factors' Mobility

- Open economy small in world capital markets (world interest rate = exogenous).
- Sector H: $Y^H(t) = C^H(t) + J^H(t) + G^H(t) + X^H(t) + C^{K,H}(t)K^H(t)$.
- Sector N: $Y^N(t) = C^N(t) + J^N(t) + G^N(t) + C^{K,N}(t)K^N(t)$.
- Households consume both $C^T = C^T\left(C^H, C^F\right)$ and C^N with $\phi = 0.35 < 1$:

$$\text{Opt. Share on N-Goods} = 1 - \alpha_C(t) = \frac{P^N(t)C^N(t)}{P_C(t)C(t)} = (1-\varphi)\left(\frac{P^N(t)}{P_C(t)}\right)^{1-\phi}$$

- Our evidence shows that L^H/L does not decline in the short-run $\Rightarrow$ To neutralize the incentives to shift resources toward sector N $\Rightarrow$ put 4 frictions into movements of L and K.
  - Capital installation costs ($\kappa > 0$):

$$J(t) = I(t) + (\kappa/2)\left(I(t)/K(t) - \delta_K\right)^2 K(t).$$

  - Sectoral hours worked and sectoral capital are imperfect substitutes ($\epsilon_L = 0.8 < \infty$, $\epsilon_K = 0.15 < \infty$):

$$\frac{L^N(t)}{L(t)} = (1-\vartheta_L)\left(\frac{W^N(t)}{W(t)}\right)^{\epsilon_L}, \qquad \frac{K^N(t)}{K(t)} = (1-\vartheta_K)\left(\frac{R^N(t)}{R(t)}\right)^{\epsilon_K}$$

  - Households consume both C^H and C^F = imperfect (and high) substitutes ($\rho = 1.3 > 1$). Note: $P = PN/PH$ and PH = TOT.

$$\hat{\alpha}_C(t) = -(1-\phi)(1-\alpha_C)\left[\hat{P}(t) + \left(1-\alpha^H\right)\hat{P}^H(t)\right].$$

Framework: CES Production and Technology Frontier

- The fourth ingredient is FBTC. Sectoral goods produced from CES PF with A- and B-augm TC:

$$Y^j(t) = \left[\gamma^j \left(A^j(t)L^j(t)\right)^{\frac{\sigma^j-1}{\sigma^j}} + \left(1-\gamma^j\right)\left(B^j(t)u^{K,j}(t)K^j(t)\right)^{\frac{\sigma^j-1}{\sigma^j}}\right]^{\frac{\sigma^j}{\sigma^j-1}},$$

- Factor-aug. productivity is made up of sym. (subscript S) and asym (subscript D) components:

$$A^j(t) = \left(A^j_S(t)\right)^{\eta}\left(A^j_D(t)\right)^{1-\eta}, \quad B^j(t) = \left(B^j_S(t)\right)^{\eta}\left(B^j_D(t)\right)^{1-\eta}, \quad u^{K,j}(t) = \left(u^{K,j}_S(t)\right)^{\eta}\left(u^{K,j}_D(t)\right)^{1-\eta}.$$

- Firms choose A^j and B^j along CES technology frontier so as to min UC^j

$$\left[\gamma^j_Z\left(A^j(t)\right)^{\frac{\sigma^j_Z-1}{\sigma^j_Z}} + \left(1-\gamma^j_Z\right)\left(B^j(t)\right)^{\frac{\sigma^j_Z-1}{\sigma^j_Z}}\right]^{\frac{\sigma^j_Z}{\sigma^j_Z-1}} \leq Z^j(t),$$

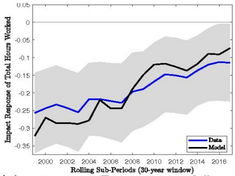
- UC^j minimization $\Rightarrow \gamma^j_Z\left(A^j(t)/Z^j(t)\right)^{\frac{\sigma^j_Z-1}{\sigma^j_Z}} = s^j_L$ where s^j_L = labor income share sector j.
- Inserting UC min into log-lin. version of technology frontier:

$$\hat{Z}^j(t) = s^j_L\hat{A}^j(t) + \left(1-s^j_L\right)\hat{B}^j(t)$$

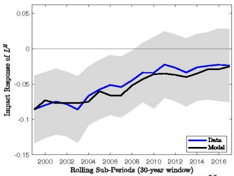
Decomposition de la Performance du Modèle

- Consider simultaneously sym. and asym tech. shocks with sym. share $\eta = 60\%$
- Objective: assess ability of model to account for labor effects of a shock to $\hat{Z}^A(\infty) = 1\%$
- Col 2-5 show agg. effects on impact of sym. and asym. shocks which are contrasted with data (col. 1)
- To assess the role of each ingredient of ref model (col. 2) $\Rightarrow$ consider 3 restricted versions.

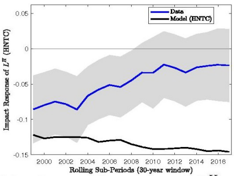
	Data	Models			
	Local Projec.	Ref.	Restricted Versions		
	(1)	(2)	(3)	(4)	(5)
A.Hours					
Total Hours, $dL(0)$	-0.15	**-0.07**	**-0.26**	**-0.42**	**-0.70**
Traded Hours, $dL^H(0)$	-0.04	**-0.03**	**-0.15**	**-0.28**	**-0.57**
Hours Share of Tradables, $d(L^H/L)(0)$	0.01	**0.00**	-0.06	**-0.14**	**-0.33**



(a) Impact Responses of L: Model (black) vs. Data (blue)



(b) Impact Responses of L^H: Model (black) vs. Data (blue)



(c) Impact Responses of L^H Model with HNTC (black) vs. Data (blue)

What's Important in What We Found

- We have shown that hours worked
  - decline because agg. tech shocks are primarily driven by sym. tech shocks
  - decline less over time as agg. tech shocks are increasingly driven by asym. tech shocks
- Why does the share of asym tech shocks increase over time?
  - $\Rightarrow$ simulate a version of our model with endo. tech. decisions to determine by how much $d\mathrm{TFPadj}^j > 0$ after a rise in Z^W
  - construct artificial time series for TFPadj^j only driven by $dZ^{W>0}$
  - var decomp reveals that 70% of the rise in asym TC is driven $dZ^W > 0$
- 2nd question: are sym and asym tech shocks alike? No, only asym TC increases stock of R&D and only in H indus.
- Our findings reconcile two literature: i) Shea 1999 and Alexopoulos 2011 find innov. shocks $dL > 0$, ii) Gali 1999 find that tech shocks $dL < 0$