IT Spillovers in Long-Run TFP
A SVAR Approach

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- The neoclassical tradition (RBC literature) in macro has treated total factor productivity (TFP) as exogenous, working against endogenous growth models
  (King & Rebelo 1999, Christiano, Eichenbaum & Trabandt 2014, 2018, vs. e.g. Romer 1990)

- The Great Recession 2008 revived interest in endogenous components in TFP for explaining long-run TFP fluctuations.

  $\rightarrow$ We explore the possibility that general-purpose technologies (GPT), in particular for the last 30 years information technologies (IT), play a role in explaining TFP fluctuations at long horizons.

- Our main analysis is estimating a structural VAR in which we identify a shock to the exogenous component of future TFP (a news shock) and a shock to the endogenous component of TFP (a shock to IT productivity, hereafter "IT shock").

- Along the way, we provide a solution to an econometric challenge in the literature on long-run productivity.

Structural Form

$$(\mathbf{AD})^{-1}\mathbf{X_t} = \mathbf{C(L)X_{t-1}} + \mathbf{s_t} \tag{1}$$

Reduced Form

$$\mathbf{X_t} = \underbrace{\mathbf{ADC(L)}}_{\mathbf{B(L)}}\mathbf{X_{t-1}} + \underbrace{\mathbf{ADs_t}}_{\mathbf{i_t}} \tag{2}$$

- AD is the impact matrix
- A is s.t. $As_t s_t' A' = i_t i_t' = \Sigma$ and $s_t s_t' = I$
- D is a rotation matrix s.t. $DD' = I \Rightarrow AD(AD)' = \Sigma$

We impose our identifying assumptions on the matrix D. ▸ Technicalities

BS identify news shocks as shocks that maximize future fluctuations in TFP. But they warn:

> A more general objection to our empirical approach would be that a number of structural shocks, which are not really "news" in the sense defined by the literature, might affect a measure of TFP in the future without impacting it immediately. Among these shocks might be research and development shocks, investment specific shocks, and reallocative shocks. Our identification (and any other existing VAR identifications) would obviously confound any true news shock with these shocks.
>
> Barsky & Sims (2011), p. 278.

$\rightarrow$ We focus on a specific subset of shocks which are "not really 'news'": shocks to the productivity of the sector that produces IT

- One strand of literature: Exogenous TFP and news shocks
  - Beaudry & Portier (2006)
  - Barsky & Sims (2011)

  Our contribution: allow in this setting the existence of an endogenous mechanism that affects future TFP

- Another strand of literature: Endogenous TFP with R&D investment as the key variable
  - Comin & Gertler (2006)
  - Moran & Queralto (2017)
  - Guerron & Jinnai (2014)

  Our contribution: provide what we think is a more convincing test for the endogenous mechanism

How should we think of this IT productivity shock?

Contextualize using a simple expanding variety model (Romer 1990)

Final good Y_t is the CES aggregate of a number A_t intermediate goods $Y_t^M(s)$:

$$Y_t = \left[\int_0^{A_t} Y_t^M(s)^{\frac{\theta-1}{\theta}} \, ds \right]^{\frac{\theta}{\theta-1}} \tag{3}$$

Expanding variety model

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Intermediate good s is Cobb-Douglas with exogenous TFP Ψ_t:

$$Y_t^M(s) = \Psi_t K_t(s)^\alpha L_t(s)^{1-\alpha} \tag{4}$$

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$\rightarrow$ letting K_t and L_t be aggregate capital and labor, final output is:

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IT sector is a separate sector that uses IT investment and its own sectoral productivity λ_t to expand A_t. ▸ IT sector in detail
$\rightarrow$ IT sector is driven by profits from selling the IT good, but its advances spill over to aggregate TFP.

The shocks

$$Y_t = \underbrace{A_t^{\frac{1}{\theta-1}}}_{\text{endogenous TFP}} \underbrace{\Psi_t}_{\text{exogenous TFP}} K_t^{\alpha} L_t^{1-\alpha}$$

$\hookrightarrow$ A news shock is $\Psi_{t+k} \uparrow$ for some $k > 0$

$\hookrightarrow$ An IT productivity shock is $\lambda_t \uparrow$, which shows up in $A_{t+j} \uparrow$ with a lag $j > 0$

So in this model, the innovation to TFP at period t is:

$$\epsilon_t^{TFP} = \underbrace{V_{t-k}}_{\text{news shock}} + \underbrace{f(IT_{t-j})}_{\text{IT productivity shock}} + \underbrace{\varepsilon_t}_{\text{surprise tech shock}} \tag{6}$$

Crucially, both lead to an increase in future TFP, with no effect on impact.

Let P be the price level (price of final good), P^{IT} the price of the IT good and relative prices be P^{IT}/P.

Intuition:

- News shock makes all sectors of the economy more productive → impacts the sectoral price P^{IT} as well as P ⇒ relative prices do not move.
- IT productivity shock makes only the IT sector more productive → impacts the sectoral price P^{IT} **only** ⇒ relative prices move!

⇒ identifying restriction: news shock does not move relative prices. Accounting for price rigidities: news shock does not move relative prices after price adjustment has taken place (6-12 quarters).

Similar identification scheme: Fisher 2006.

Recall that the innovation in TFP at time t is:

$$\epsilon_t^{TFP} = \underbrace{V_{t-k}}_{\text{news shock}} + \underbrace{f(IT_{t-j})}_{\text{IT productivity shock}} + \underbrace{\varepsilon_t}_{\text{surprise tech shock}}$$

1. The news shock V_{t-k} maximizes the FEV of future TFP, with a zero impact effect, subject to the restriction that it has no effect on the relative price RP at a small number of quarters;

2. The IT productivity shock maximizes the remaining FEV of future TFP, with a zero impact effect;

3. The tech shock ε_t is considered as a residual shock and is left unrestricted (unidentified).

We run a SVAR using aggregate, quarterly US data. The data vector is:

$$\mathbf{X_t} = \begin{bmatrix} TFP_t \\ SP_t \\ IT_t \\ GDP_t \\ C_t \\ RP_t \end{bmatrix} \tag{7}$$

- $RP = \pi^{IT}/\pi^{CPI}$.
- All variables are real (except price indexes) and in log levels (except for RP, which is in growth rates).
- The dataset ranges from 1989:q1 - 2017:q2.

- Recall: dataset is quarterly and covers 1989:q1-2017-q2.

- One lag (as suggested by BIC and HQ).

- Horizon of FEV-maximization: 60 quarters.

- Restriction on relative prices after a news shock is imposed at 8 quarters.
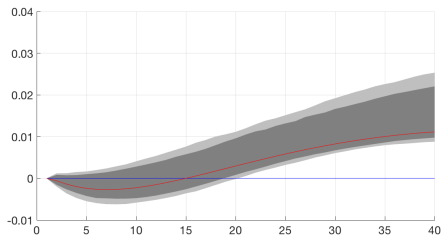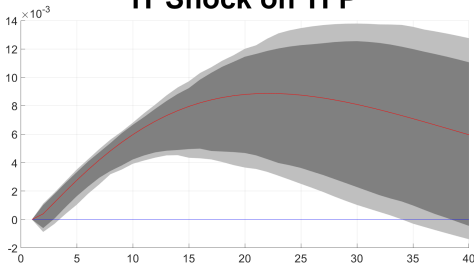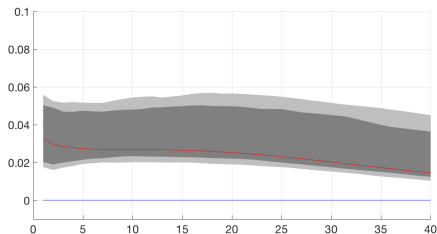
News Shock on Real SP
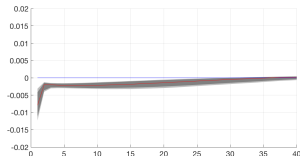
IT Shock on Real SP
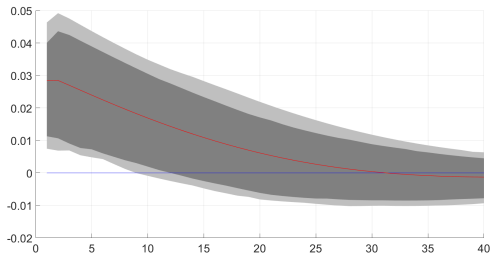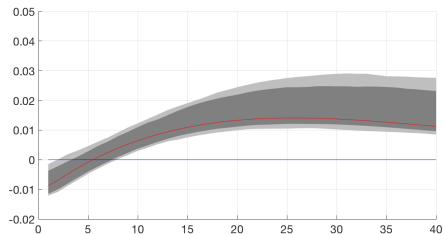
News Shock on Real IT Investment

IT Shock on Real IT Investment
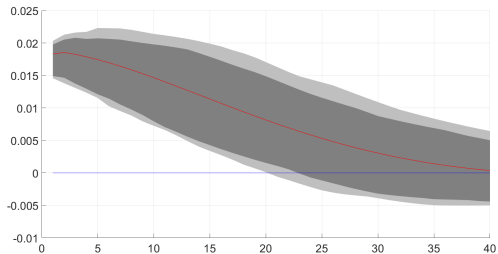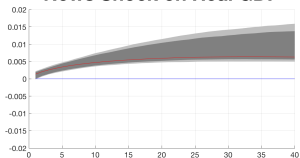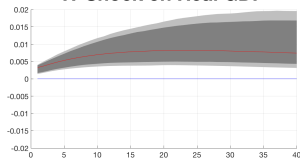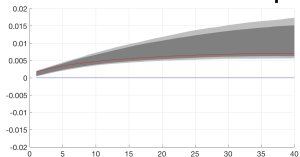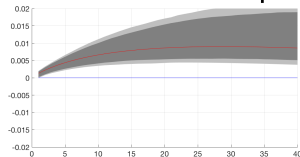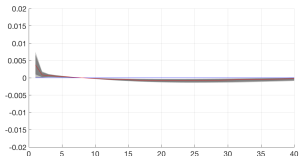
	News	IT	Total
TFP	0.20384	0.52596	0.72981

For BS, FEV of news was 45%.

Interpretation

1. Shape and timing of the responses reflect ...
   - both the Barsky & Sims result;
   - as well as the the conjecture that the IT shock looks similar to news along certain dimensions;
   - but relative prices do indeed introduce a margin of difference between the two shocks.

2. Shares of FEV of TFP explained ...
   - are also in line with the Barsky & Sims result;
     (for BS, news explains around 45%, compared to 20% here)
   - yet suggest that the IT shock plays an important role as well (around 52%).
   - And indeed the IT shock *complements* the news shock, instead of substituting for it.
     For BS, the single identified shock explains around 45%, while our two identified shocks explain around 73%.

- Different variables
  - Add the Michigan index of consumer confidence (expected business conditions 5 years ahead)

  - Replace IT prices with capital prices (following Comin & Gertler)

  - Replace CPI inflation with PCE inflation

- Different horizons at which we impose the restriction on relative prices for the news shock
  $\rightarrow$ ran 6, 8, 10, 12 and 16 quarters.

- Increase the number of lags (2)

- Check whether VAR is information-sufficient to identify the news shock (Forni-Gambetti test) (p-val of 12%)

Shutting off negative IT productivity shocks
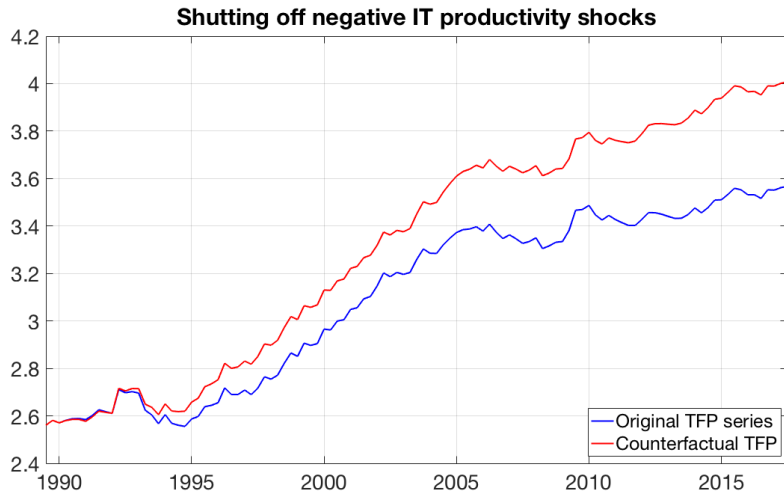
- Provided a test for the role of IT as an example of GPTs in explaining fluctuations in long-run TFP, and in doing so, overcame an econometric challenge prevalent in the literature on long-run productivity.

- The results show that by controlling for the presence of news shocks, IT productivity shocks are important drivers of TFP fluctuations at long horizons.

- This result does not contrast however with the findings of the news shock literature since we still find that news also play a significant role in explaining TFP.

- Moreover, IT productivity shocks can be thought of as giving more microfoundations to what classical news shocks carry information on.

- Show the identification assumption in the structural model.

- Technically, should do a VECM due to cointegration and wanting to have variables in the VAR as growth rates rather than levels...

- Dig deeper: IT is just an example of GPTs for the last 30 years $\hookrightarrow$ could redo analysis for different time periods with different GPTs (electricity in 1920s, airplane industry in 1960s ...)

- Use a fully structural model to see if we can find interesting interactions between the two shocks? $\hookrightarrow$ In particular, we're thinking of noise shocks on IT productivity

- But there are also other shocks that are similar to news shocks and yet not news shocks in the Barsky & Sims sense: reallocative shocks, shocks to inventories, etc...
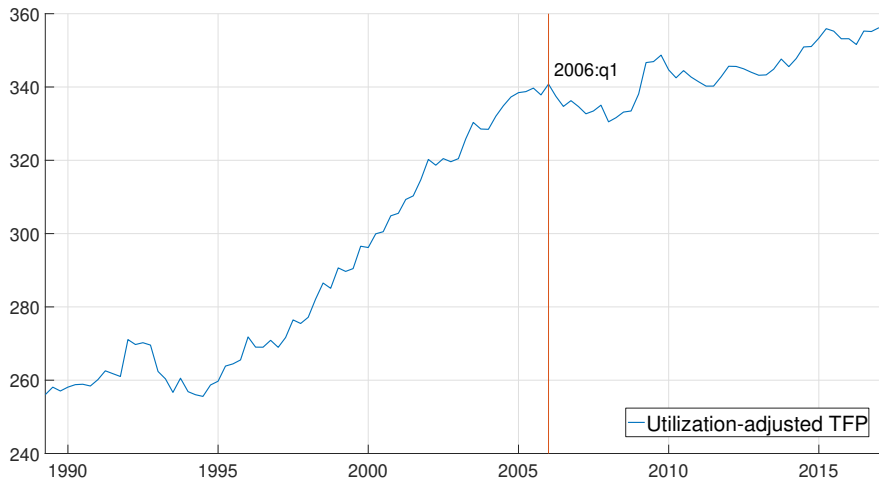
Table 1
Forecast error variance decomposition.

	$h=1$	$h=4$	$h=8$	$h=16$	$h=24$	$h=40$
TFP	0.000	0.062	0.126	0.269	0.366	0.454
	(0.00)	(0.06)	(0.11)	(0.14)	(0.15)	(0.16)
Consumption	0.050	0.234	0.377	0.493	0.524	0.507
	(0.09)	(0.18)	(0.24)	(0.27)	(0.27)	(0.26)
Output	0.111	0.091	0.242	0.382	0.429	0.431
	(0.07)	(0.10)	(0.18)	(0.23)	(0.24)	(0.24)
Hours	0.622	0.200	0.105	0.092	0.094	0.089
	(0.23)	(0.16)	(0.13)	(0.15)	(0.16)	(0.15)
Stock price	0.140	0.200	0.185	0.189	0.193	0.181
	(0.17)	(0.20)	(0.20)	(0.21)	(0.22)	(0.21)
Confidence	0.245	0.343	0.353	0.333	0.310	0.286
	(0.21)	(0.22)	(0.22)	(0.22)	(0.20)	(0.18)
Inflation	0.138	0.220	0.226	0.205	0.191	0.180
	(0.18)	(0.18)	(0.15)	(0.15)	(0.14)	(0.14)
Total TFP	1.000	0.948	0.943	0.951	0.948	0.910
Total output	0.731	0.282	0.364	0.451	0.491	0.520

The letter h refers to the forecast horizon. The numbers denote the fraction of the forecast error variance of each variable at various forecast horizons to our identified news shock. Standard errors, from a bootstrap simulation, are in parentheses. "Total TFP" shows the total variance of TFP explained by our news shock and the TFP innovation combined. "Total output" shows the total variance of output explained by the news shock and the TFP innovation combined.

‹ **Return**

Production function for IT goods:

$$V_{i,t} = \lambda_t \Psi_t f(S_{i,t}) \tag{8}$$

where $S_{i,t}$ is investment by producer i in IT goods and λ is the productivity of the IT sector.

The IT producer's problem is to max discounted profits $J_{i,t+1}$
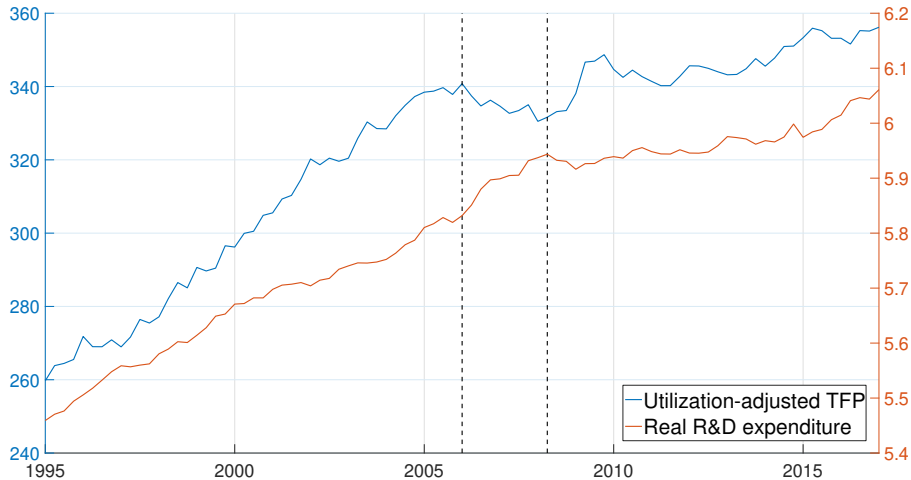
$$\max_{S_{i,t}} \mathbb{E}(\Lambda_{t,t+1}, J_{i,t+1})\lambda_t \Psi_t f(S_{i,t}) - P_t^{IT} S_{i,t} \tag{9}$$

FOC:

$$P_t^{IT} = \mathbb{E}(\Lambda_{t,t+1}, J_{i,t+1})\lambda \Psi_t f_1 \tag{10}$$

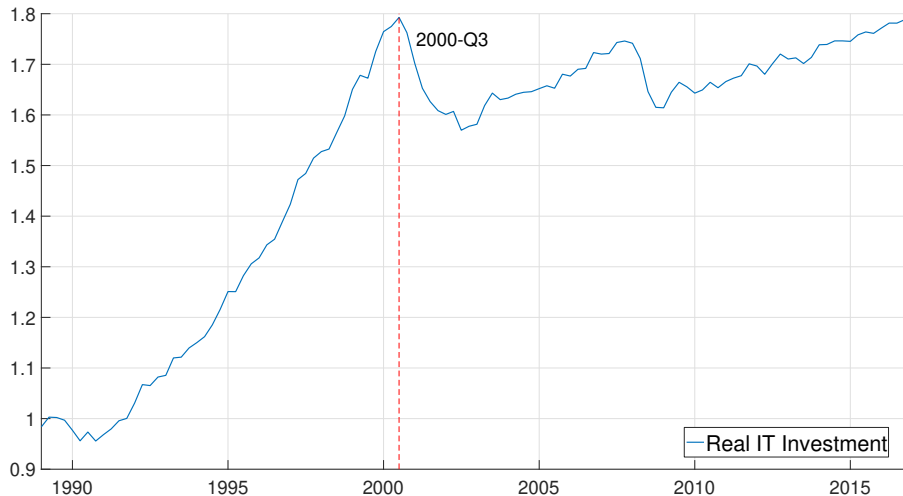‹ Return

Timing: RD drop vs TFP drop

$$D = \begin{bmatrix} d_{11} & \gamma_{12} & \gamma_{13} & d_{14} & \cdots \\ d_{21} & \gamma_{22} & \gamma_{23} & d_{24} & \cdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \end{bmatrix} \tag{11}$$

- Indifferent over d_{ij} as long as D is orthogonal
- A_{γ_2} is the impact response to a news shock
- A_{γ_3} is the impact response to a IT productivity shock
- First element of both A_{γ_2} and A_{γ_3} is zero due to the no-contemporaneous effect of both shocks on TFP
- A_{γ_2} is such that the FEV of TFP is maximized subject to zero long-run effect on RP
- A_{γ_3} is maximizing the remaining FEV of TFP

◄ Return