Spillover Effects of Information and Communication Technology on Future TFP using a Structural VAR Approach

Marco Brianti and Laura Gati

Boston College

June 2018

Motivation

- Literature agrees on the importance of Total Factor Productivity (TFP) in driving long-run economic performance.
- However, less agreement on the underlying driver of TFP.
- 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.

- However, an increase in IT investment affects TFP with some delays. Therefore this shock is likely to look very similar to a standard news shock.

Motivation

- Our main analysis is estimating a structural VAR in which we identify a shock to the exogenous component of future TFP (hereafter *news shock*) and a contemporaneous shock which incentivizes investment in information and technology stock (hereafter *IT shock*).

- As a support for our identification we design a 2-sector general equilibrium model which features both investment in IT and news shocks.

Preview of the Results

- IT shocks drive about half of long-run TFP fluctuations in our sample.
- News shocks drive approximately one fifth $\Rightarrow$ Still relevant but - once appropriately cleaned from IT shocks - less important then found previously in the literature.
- Our structural model points out that relative prices can be used to disentangle the two.

VARs - A quick recap

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

Related literatures

- 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

Identification: relative prices

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:

- As long as the technology improvement heralded by the news shock does not realize, relative prices should not move.
- An increase in IT productivity shock makes only the IT sector more productive $\rightarrow$ impacts the sectoral price P^{IT} **only** $\Rightarrow$ relative prices move!

$\Rightarrow$ 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.

Identification strategy overall

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).

Empirical analysis

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

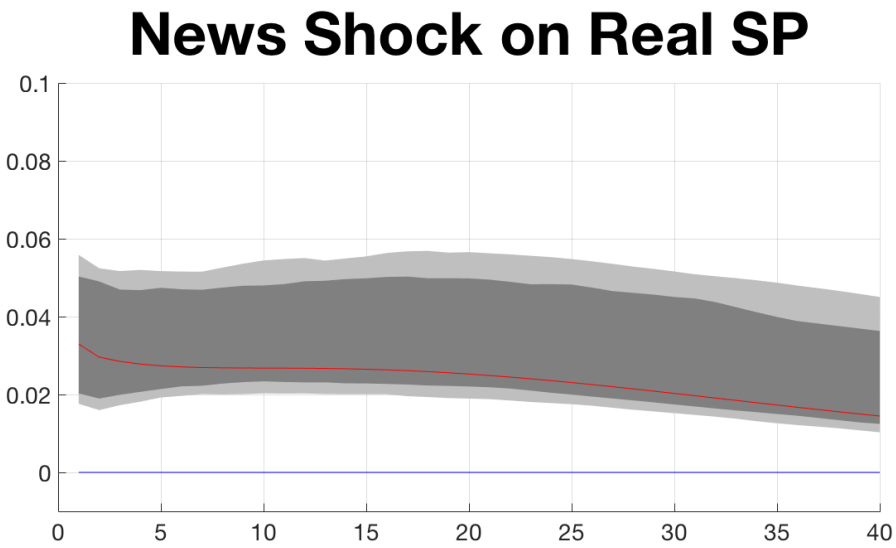
$$\mathbf{X_t} = \begin{bmatrix} TFP_t \\ SP_t \\ IT_t \\ GDP_t \\ C_t \\ RP_t \end{bmatrix} \tag{3}$$

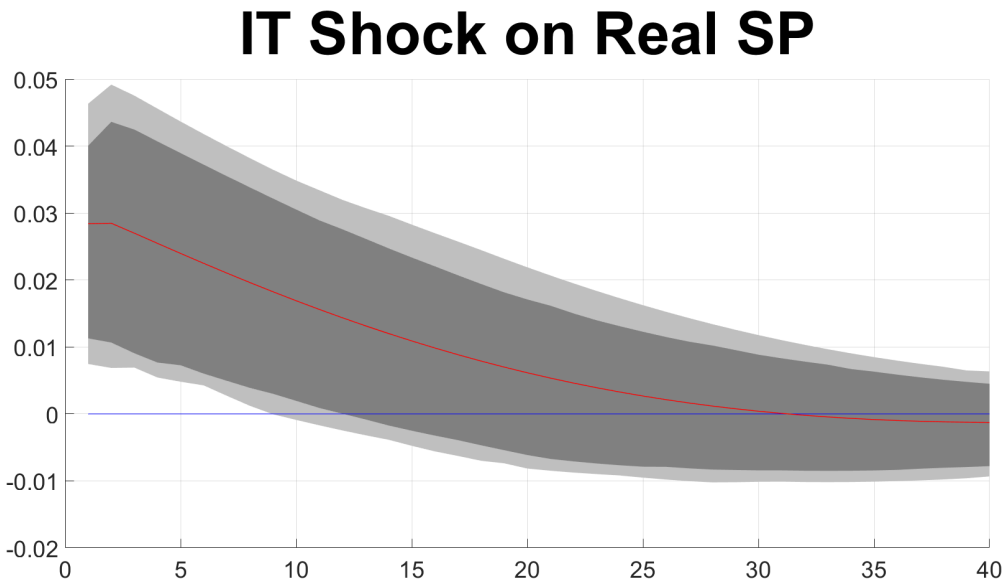
- $RP = \pi^{IT} / \pi^{CPI}$.
- All variables are real (except price indexes) and in log levels (except for RP, which is in growth rates).
- The dataset ranges from 1989:q1 - 2017:q2.

Our favorite specification

- 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.

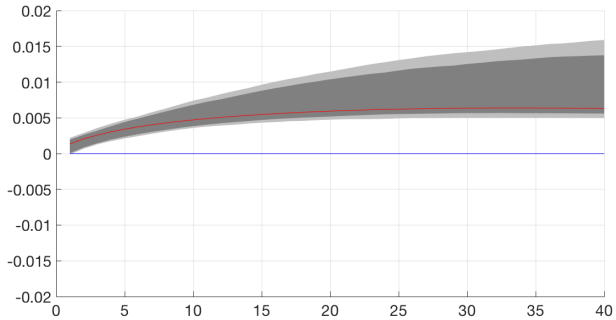
Real SP500 response to both shocks



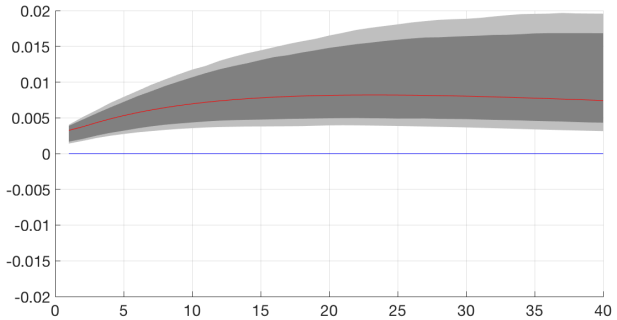


Other responses to both shocks

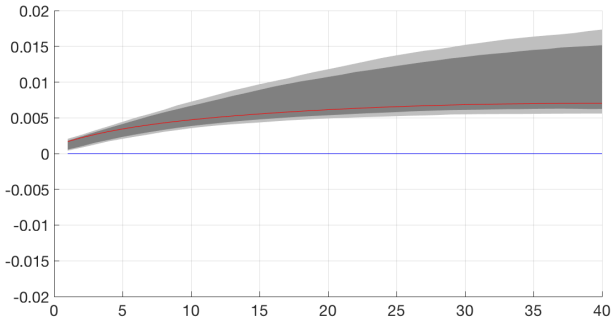
News Shock on Real GDP



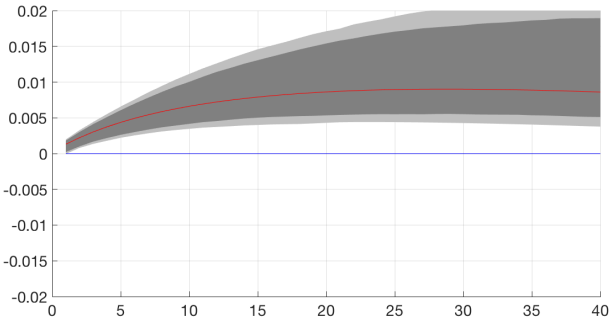
IT Shock on Real GDP



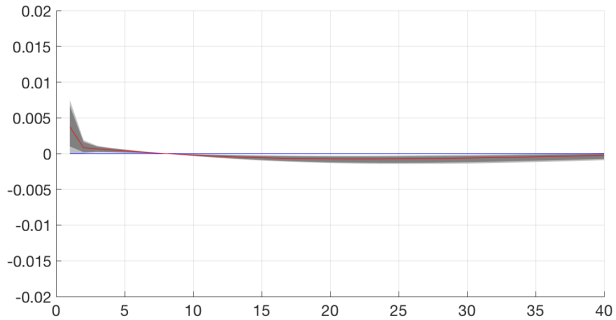
News Shock on Real Consumption



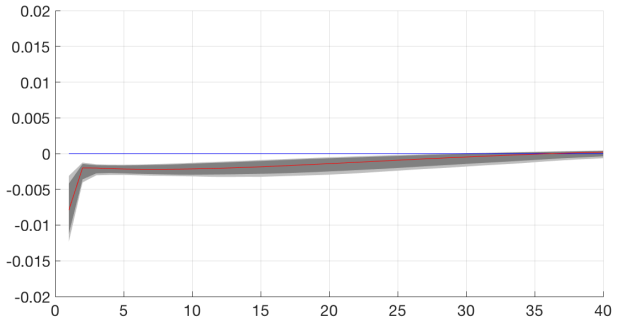
IT Shock on Real Consumption



News Shock on Relative Price



IT Shock on Relative Price



FEV explained by the two shocks at 60 periods

	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.

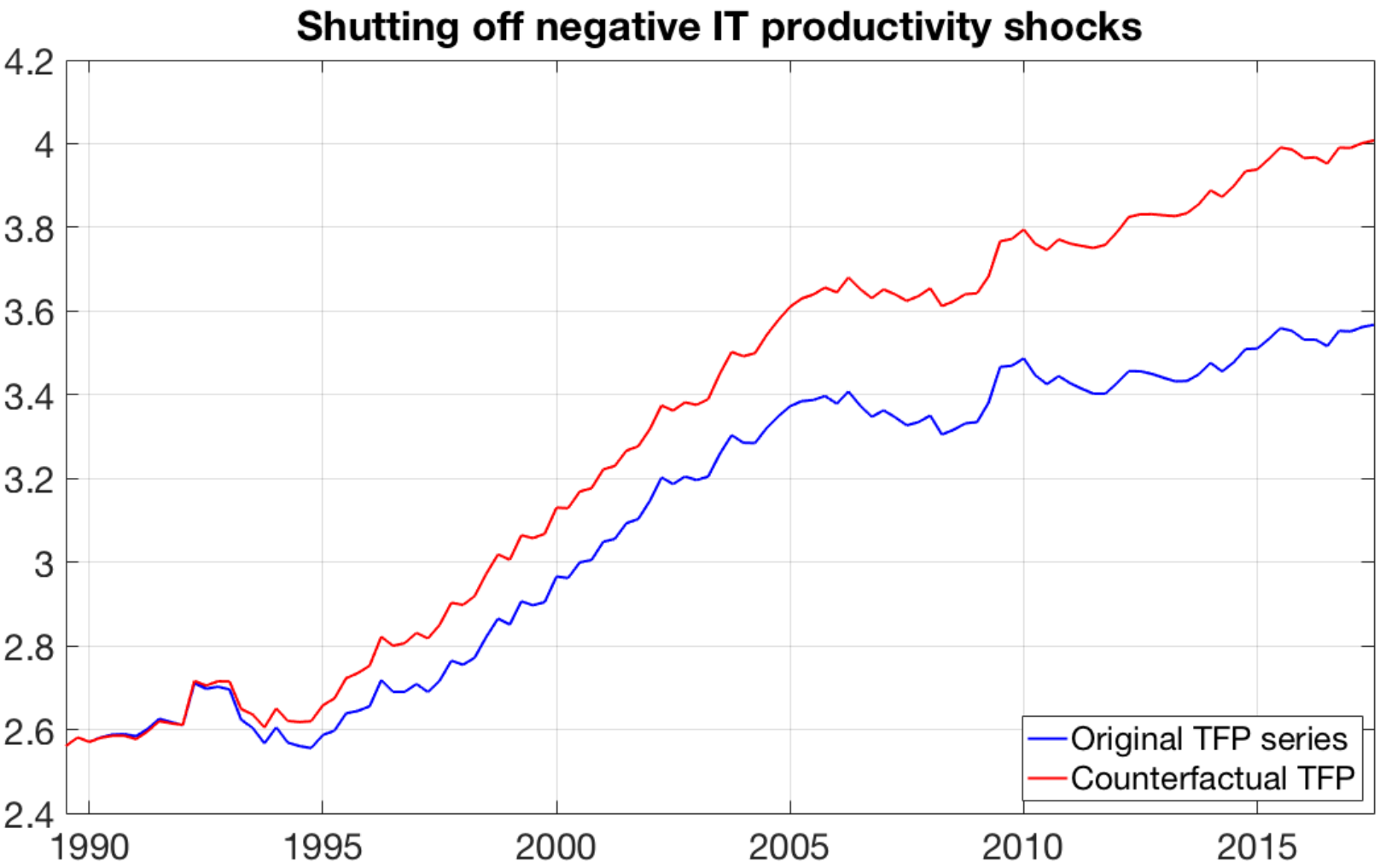
2. Shares of FEV of TFP explained ...
   - are also in line with the Barsky & Sims result;
     (for BS, news explains around 45%, compared to 20% here)
   - yet suggest that the IT shock plays an important role as well (around 52%).
   - And indeed the IT shock *complements* the news shock, instead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

Robustness checks

- 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%)

A counterfactual



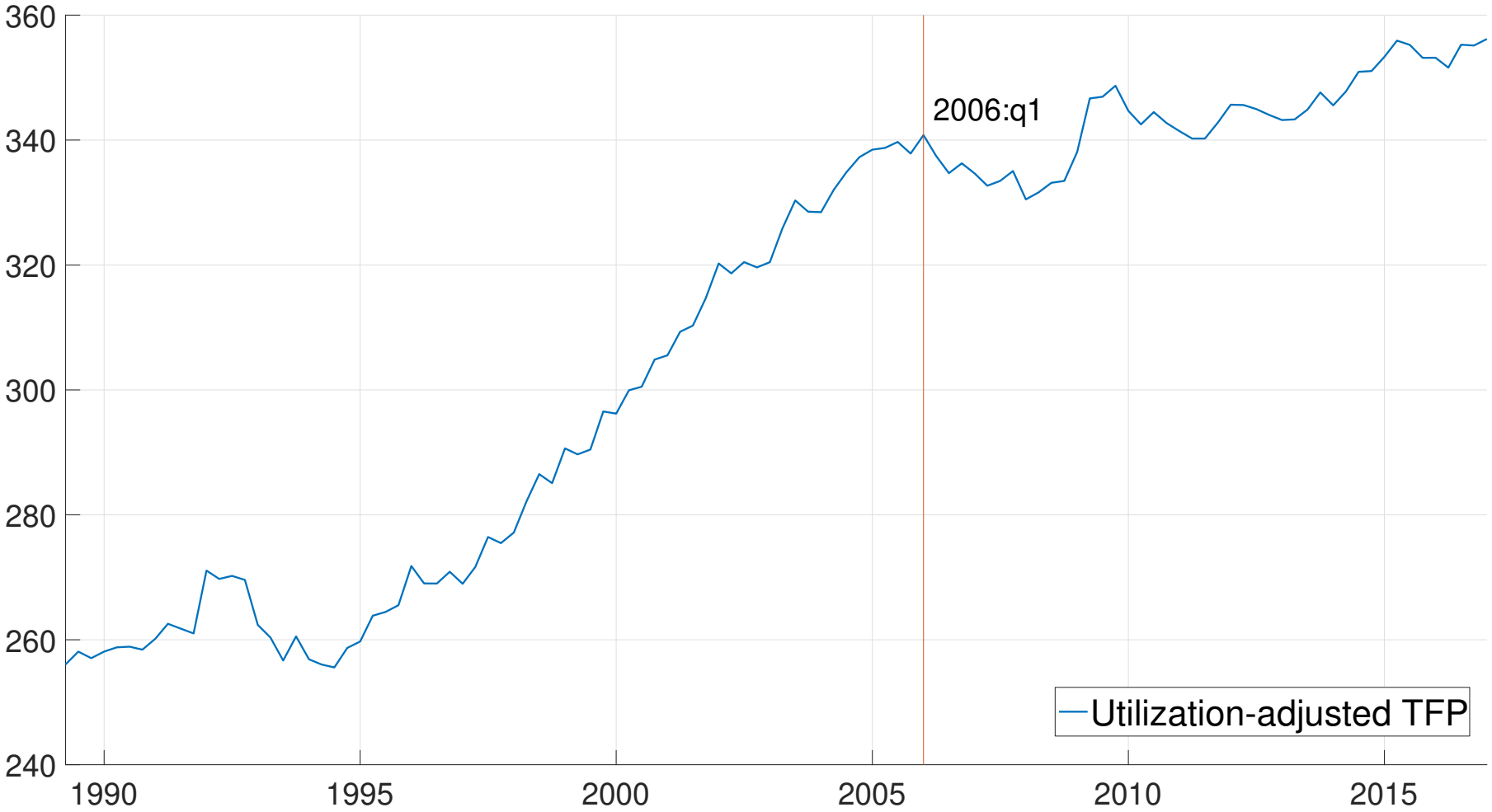
Conclusion

- 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.

Work ahead

- 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...

The current TFP slowdown



Barsky & Sims FEV of TFP explained

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 of IT goods

Production function for IT goods:

$$V_{i,t} = \lambda_t \Psi_t f(S_{i,t}) \tag{4}$$

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 $J_{i,t+1}$

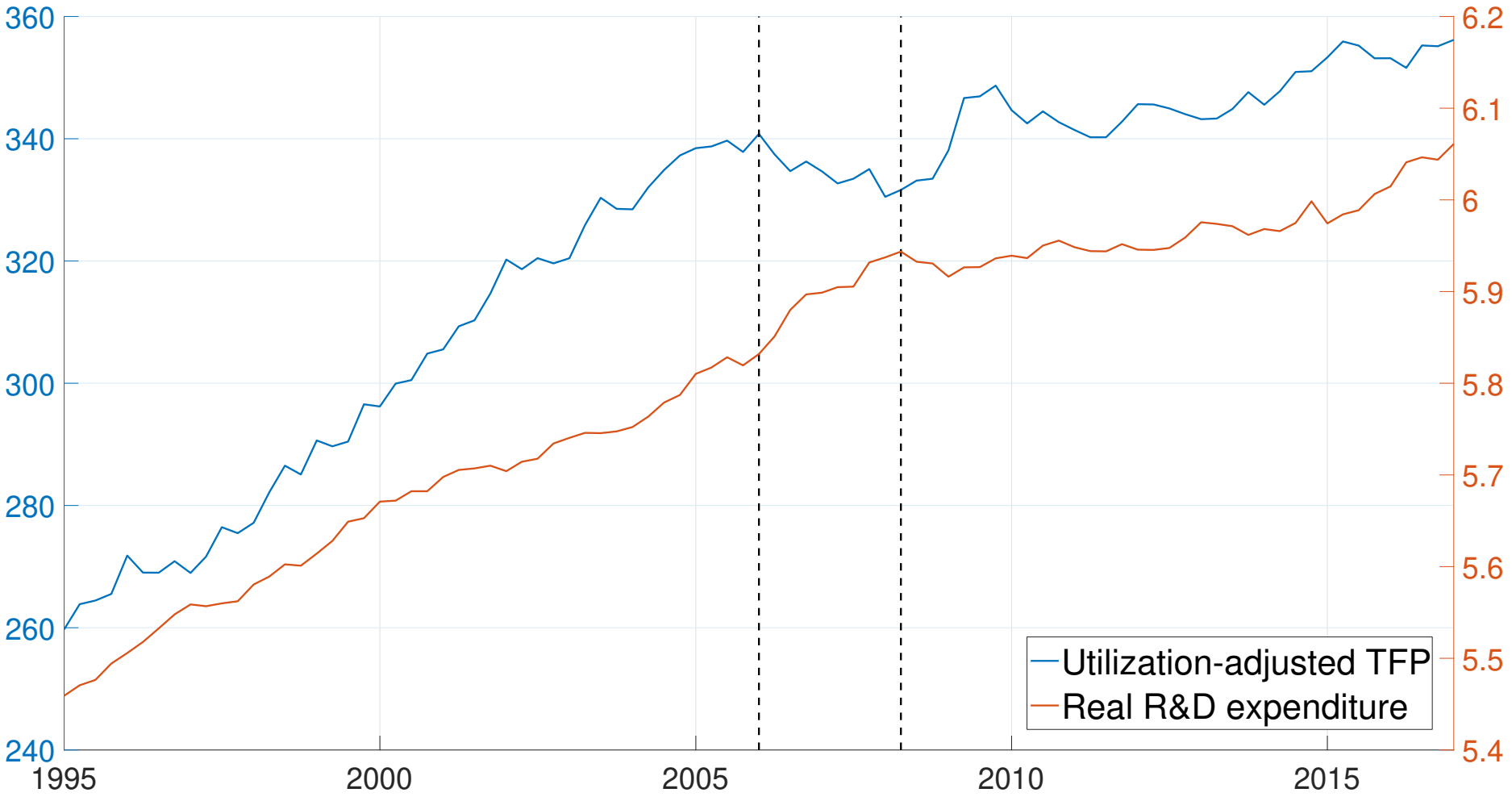
$$\max_{S_{i,t}} \mathbb{E}(\Lambda_{t,t+1}, J_{i,t+1}) \lambda_t \Psi_t f(S_{i,t}) - P_t^{IT} S_{i,t} \tag{5}$$

FOC:

$$P_t^{IT} = \mathbb{E}(\Lambda_{t,t+1}, J_{i,t+1}) \lambda \Psi_t f_1 \tag{6}$$

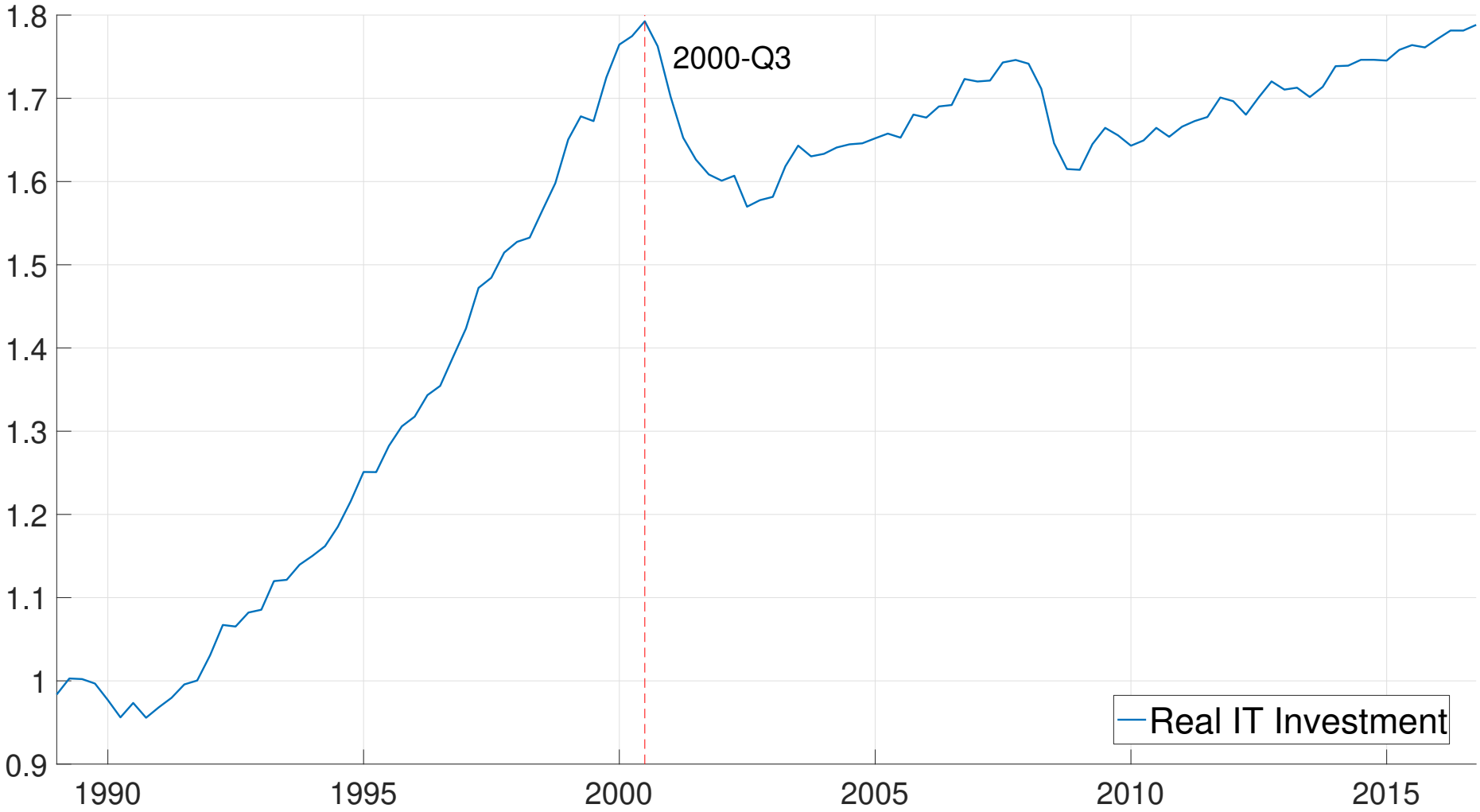
Return

Timing: RD drop vs TFP drop



Return

IT investment: a drop at the right time



Return

Identification Strategy

$$D = \begin{bmatrix} d_{11} & \gamma_{12} & \gamma_{13} & d_{14} & \cdots \\ d_{21} & \gamma_{22} & \gamma_{23} & d_{24} & \cdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \end{bmatrix} \tag{7}$$

- Indifferent over d_{ij} as long as D is orthogonal
- $A\gamma_2$ is the impact response to a news shock
- $A\gamma_3$ is the impact response to a IT productivity shock
- First element of both $A\gamma_2$ and $A\gamma_3$ is zero due to the no-contemporaneous effect of both shocks on TFP
- $A\gamma_2$ is such that the FEV of TFP is maximized subject to zero long-run effect on RP
- $A\gamma_3$ is maximizing the remaining FEV of TFP

◂ Return