

The Impact of Technological Change

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Introduction

Research Questions

How does technological change affect productivity?

How important is technological change for the economy?

Theory

- Real Business Cycle (RBC) literature (Kydland and Prescott, 1982)
 - Technology shocks are the only shocks that affect aggregate productivity **immediately** (with **permanent** and/or **transitory** effects)
 - Technology shocks are the main driving force of cyclical fluctuations

Empirics

- How to measure the impact of technological change on economic activity?
- There are two approaches:
 - One is to apply structural identification schemes to identify technology shocks from macroeconomic data.
 - The other is to use direct measures of technological change.

- The technology shock defined in the RBC literature has to be the only shock with positive impact on productivity.
- Problem 1: The shock with impact effect on productivity cannot be a technology shock.
- Micro studies: considerable time lag between the invention of new technologies and their adoption in production at such a large scale as the diffusion to be reflected in measures of aggregate productivity.
- Problem 2: Empirical studies also question the RBC idea that this shock is the main source of macroeconomic fluctuations.

If not technology then what shock can have an immediate effect on productivity?

- An unexpected improvement in productivity due to sudden changes in policies or management practices that promote more production.
- I call this shock an **unanticipated** (*surprise/current*) **productivity shock**.

What shock can have a permanent but no immediate effect on productivity?

- Technological news literature (Beaudry and Portier, 2006)
- Mere news about emerging technologies that potentially increase future productivity have an effect on the economy.
- I call this shock a **news** (*slow diffusing/anticipated productivity*) **shock**.

What shock can have a permanent but no immediate effect on productivity?

- Alexopoulos (2011) uses new book titles in the category technology as proxy for the adoption of technological innovations.
- Baron and Schmidt (2017) use counts of standards in the categories ICT and electronics.
- I call the shock on any of these two indices a **technology shock**.

This paper in a nutshell

- Estimates a linear VAR model.
- Identifies the three productivity shocks (using short- and medium-run identification schemes).
- Compares the effects of the three shocks on macro aggregates through impulse response functions.
- Investigates which of these shocks plays a more important role in driving macroeconomic fluctuations by applying the forecast error variance decomposition.

Related empirical literature

Unanticipated productivity shocks:

Basu, Fernald, and Kimball (AER, 2006), Galí (AER, 1999)

News shocks:

Beaudry and Portier (AER, 2006), Beaudry and Portier (JEL, 2014)

Barsky and Sims (JME, 2011), Kurmann and Mertens (AER, 2014)

Forni and Gambetti (JME, 2014)

Direct measures of technological change:

Alexopoulos (AER, 2011), Baron and Schmidt (WP, 2017)

...to the empirical literature on productivity shocks

- With the identification of technology shocks along with the unanticipated and anticipated productivity shocks.

... to the literature that develops direct measures of technological change

- With the comparison of several indicators and the evaluation of their performance in a horse-race of potential important sources of macroeconomic fluctuations.

...to the theoretical literature that investigates the effect of technology shocks on economic activity

- With empirical evidence in favor of theoretical models that depart from the exogeneity assumption on productivity.

Main results

- The two technological change indicators give similar results.
- The technology shock has much stronger short- and medium-run effects on all macroeconomic variables than the unanticipated productivity shock. The differences between the technology and news shock are mostly apparent in the short-run.
- An important result is that these three shocks have different roles in driving macroeconomic fluctuations, depending on the forecast horizon.

1. Introduction
2. Empirical Approach
3. Data
4. Results
5. Conclusions

Empirical Approach

$$Y_t = c + \sum_{i=1}^p \Phi_i Y_{t-i} + \epsilon_t,$$

where Y_t is a vector of k endogenous variables modeled as the sum of an intercept c , p lags of the same endogenous variables and $\epsilon_t \sim WN(0, \Sigma)$, while Φ_i are the matrices containing the VAR coefficients.

Linear mapping between residuals and structural shocks:

$$\epsilon_t = Au_t,$$

assuming that A is nonsingular.

Structural shocks are white noise distributed $u_t \sim WN(0, I_m)$.

To identify the structural shocks from the reduced-form innovations, $k(k-1)/2$ additional restrictions on A are needed.

Short-run identification

- Unanticipated productivity shock: The only shock that affects TFP on impact.
- Technology shock: The shock with no impact effect on TFP, *that has an impact effect on the measure of technological change.*
- News shock: The shock with no impact effect on TFP and the measure of technological change, *that has an impact effect on consumer confidence.*

Medium-run identification

- Unanticipated productivity shock: The only shock that affects TFP on impact.
- News shock: The shock with no impact effect on TFP, *that has the largest effect on TFP in the medium-run.*

Data

- **Total Factor Productivity:** adjusted for factor utilization (Basu, Fernald and Kimball (2006)) (logged)
- **Measure of technological change:** Bowker book-based indicator (TECH) or technological standardization-based indicator (US ICT+ELEC Standards)
- **Measure of consumer confidence:** Index of Consumer Sentiment from the Michigan Survey of Consumers
- **Output:** GDP nonfarm (logged, real, per capita)
- **Consumption:** sum of personal consumption expenditures for nondurable goods and services (logged, real, per capita)
- **Investment:** sum of personal consumption expenditures on durable goods, and gross private domestic investment (logged, real, per capita)
- **Hours worked:** Hours of all persons in the nonfarm business sector

I estimate the model using annual/quarterly data for the US for the sample period 1964Q1-2012Q4 with two and four lags, depending on data frequency.

Results

Comparison of impulse responses to technology shocks

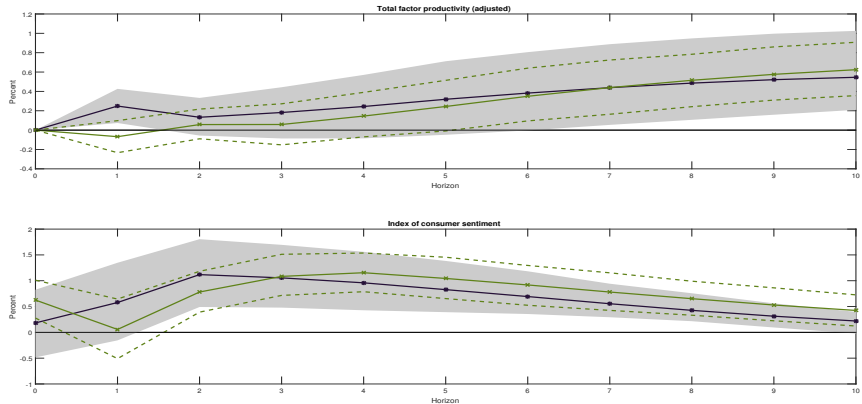


Figure 1: Black starred line defines the IRF to a technology shock on variable TECH, and the green crossed line represents the IRF to a shock on variable US ICT+ELEC Standards, both with corresponding 68% confidence interval.

Comparison of impulse responses to technology shocks

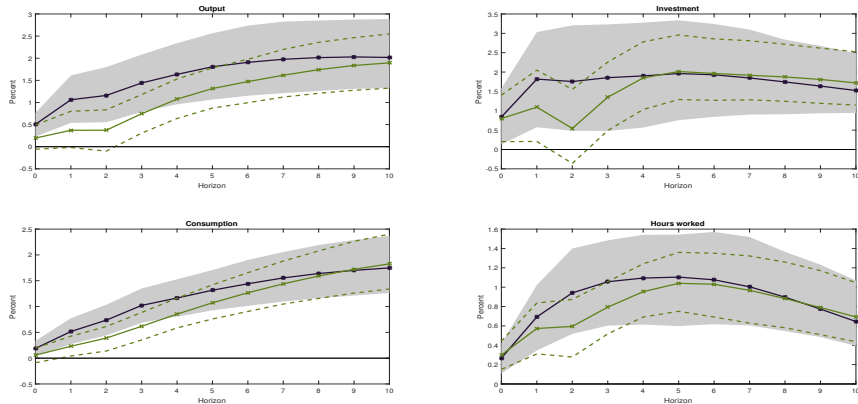


Figure 2: Black starred line defines the IRF to a technology shock on variable TECH, and the green crossed line represents the IRF to a shock on variable US ICT+ELEC Standards, both with corresponding 68% confidence interval.

Comparison of technology shocks: Forecast error variance decomposition

	Horizon				
	2	8	10	20	30
Total factor productivity (adjusted)					
TECH shock	1.82	6.49	10.66	26.62	31.98
US ICT+ELEC shock	0.50	2.41	5.49	34.12	48.57
Index of consumer sentiment					
TECH shock	1.69	15.68	16.65	16.76	16.79
US ICT+ELEC shock	1.99	17.04	18.89	20.09	20.12
Output					
TECH shock	9.74	28.23	32.49	41.94	44.67
US ICT+ELEC shock	1.49	25.4	36.71	65.65	73.89
Consumption					
TECH shock	12.03	48.5	55.31	73.46	79.55
US ICT+ELEC shock	2.58	48.08	62.45	87.69	91.32
Investment					
TECH shock	4.51	12.28	14.06	16.79	17.36
US ICT+ELEC shock	2.48	15.01	18.96	27.87	31.46
Hours worked					
TECH shock	7.6	28.95	32.51	34.06	33.82
US ICT+ELEC shock	8.3	18.97	35.76	37.16	37.39

Comparison of impulse responses to unanticipated productivity and technology shocks

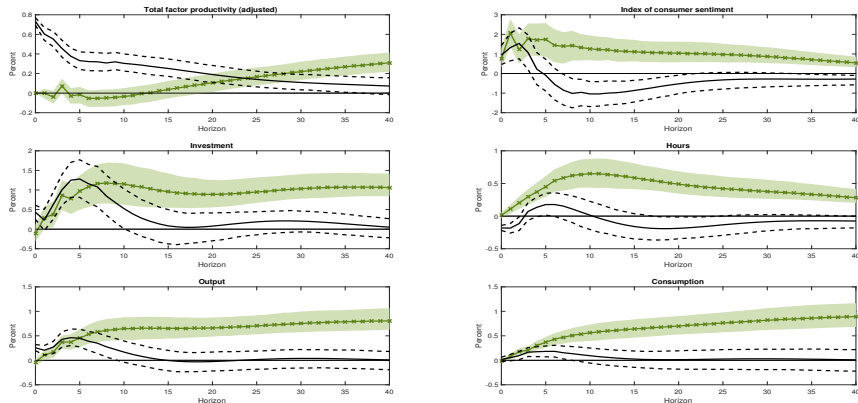


Figure 3: The green crossed line represents the IRF to a technology shock and the black solid line represents the IRF to an unanticipated productivity shock, both with corresponding 68% confidence intervals.

Comparison of impulse responses to news and technology shocks

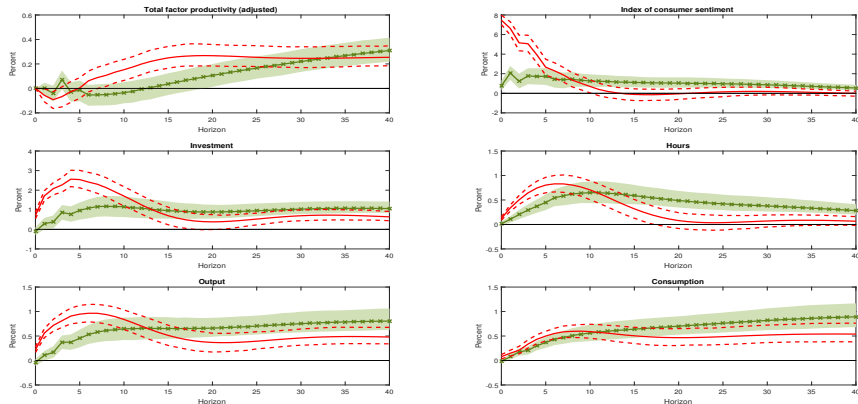


Figure 4: The green crossed line represents the IRF to a technology shock and the red solid line defines the IRF to a news shock identified with SRI, both with corresponding 68% confidence intervals.

Comparison of productivity shocks: Forecast error variance decomposition

	Horizon				
	2	8	10	20	30
Total factor productivity (adjusted)					
TFP shock	69.65	41.77	35.5	14.74	9.42
US ICT+ELEC shock	0.49	5.73	11.71	32.3	36.6
News Shock	1.07	19.3	21.87	19.72	16.56
Index of consumer sentiment					
TFP shock	3.16	5.59	5.54	5.65	5.64
US ICT+ELEC shock	8.51	14.38	14.89	14.95	15.07
News Shock	79.84	56.86	54.41	52.37	52.25

Comparison of productivity shocks: Forecast error variance decomposition

	Horizon				
	2	8	10	20	30
Output					
TFP shock	8.92	3.29	2.56	1.23	0.92
US ICT+ELEC shock	9.65	32.32	35.22	40.42	41.37
News Shock	48.54	32.48	29.02	20.36	17.49
Consumption					
TFP shock	3.35	0.69	0.5	0.21	0.19
US ICT+ELEC shock	14.89	38.36	40.39	43.31	43.52
News Shock	32.31	23.71	21.92	16.76	14.78
Investment					
TFP shock	9.65	6.52	5.81	4.04	3.58
US ICT+ELEC shock	6.62	19.81	22.86	29.64	31.2
News Shock	43.21	40.33	37.75	29.32	26.59
Hours worked					
TFP shock	1.82	2.24	2.17	2.37	2.39
US ICT+ELEC shock	10.72	27.02	27.28	27.15	27.13
News Shock	26.45	23.08	21.09	19.14	19.16

Comparison of impulse responses to technology and news shocks

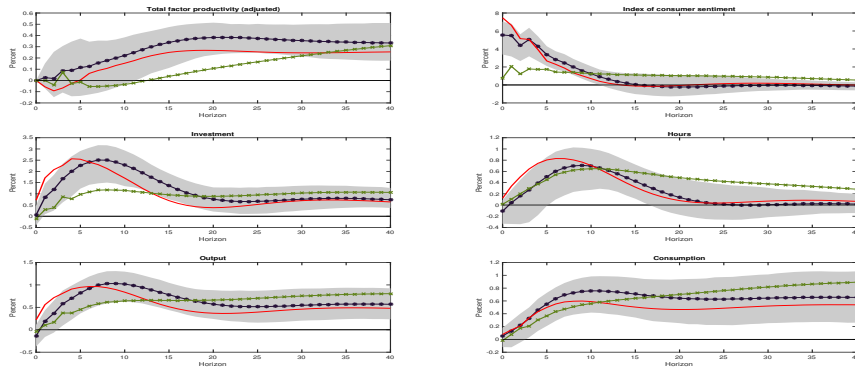


Figure 5: The dark blue circled line defines the news shock obtained using MRI, with a truncation horizon of 10 years. The shaded area is the corresponding 68% confidence interval. The green crossed line represents the impulse responses to a technology shock, and the red solid line represents the impulse responses to a news shock, obtained with SRI.

Comparison of impulse responses to technology and news shocks

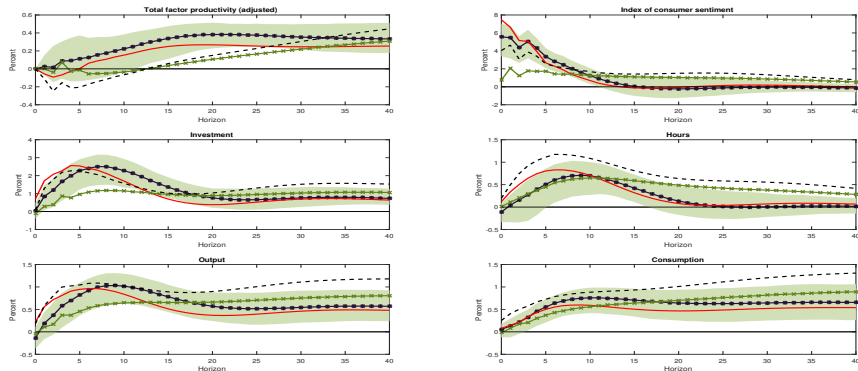


Figure 6: The dark blue circled line defines the news shock obtained using MRI, with a truncation horizon of 10 years. The shaded area is the corresponding 68% confidence interval. The black dotted line defines the news shock obtained using MRI, with a truncation horizon of 20 years. The green crossed line represents the impulse responses to a technology shock, and the red solid line represents the impulse responses to a news shock, obtained with SRI.

Conclusions

Conclusions

- My findings indicate that the two technological change indicators used can be used interchangeably as they give similar results.
- When comparing the technology shocks with the other shocks, I observe that the technology shock has much stronger short- and medium-run effects on all macroeconomic variables than the unanticipated productivity shock.
- When comparing the technology with the news shock, I find that the differences between the two shocks are mostly apparent in the short-run.
- News shocks play a more important role than technology shocks at business cycle frequencies, while in the medium- to long-run technology shocks take the lead. Unanticipated productivity shocks do not seem to be a significant source of aggregate fluctuations regardless of the forecast horizon.

Methodology

Short-Run Identification Scheme

$$AA' = \Sigma$$

Innovations are orthogonalized by applying the Cholesky decomposition to the covariance matrix of the residuals, Σ .

Medium-Run Identification Scheme

- h -step ahead forecast error: $Y_{t+h} - Y_{t+h|t-1} = \sum_{\tau=0}^h B_{\tau} \tilde{A} D u_{t+h-\tau}$, $DD' = I$
- Contribution of shock j to the variance of variable i at horizon h :

$$\Xi_{i,j}(h) = \frac{e_i' (\sum_{\tau=0}^h B_{\tau} \tilde{A} D e_j e_j' D' \tilde{A}' B_{\tau}') e_i}{e_i' (\sum_{\tau=0}^h B_{\tau} \tilde{A} \tilde{A}' B_{\tau}') e_i} = \frac{(\sum_{\tau=0}^h B_{i,\tau} \tilde{A} \theta \theta' \tilde{A}' B_{i,\tau}')}{(\sum_{\tau=0}^h B_{i,\tau} \tilde{A} \tilde{A}' B_{i,\tau}')}$$

- Choose θ such that $\Xi_{TFP,NS}(h)$ is maximized at horizon $h = 40$ quarters.