Turbulent Business Cycles[1]

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Background

- Turbulence rises in recession
  - Increased churn of firm productivity ranking (Bloom, et al. 2018)
- Open questions:
  1. What are the macro and reallocation effects of turbulence?
  2. What's the transmission mechanism?
  3. What policy interventions are effective?

What's turbulence?

- Consider firm-level TFP process

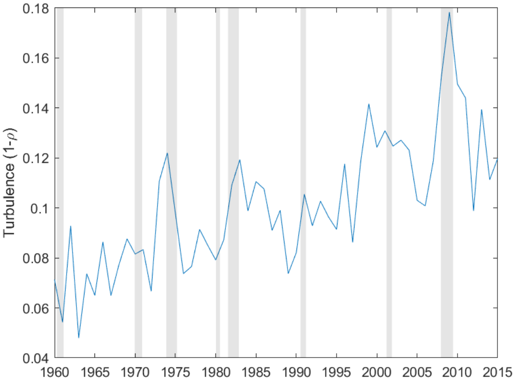
$$z_{j,t+1} = \begin{cases} z_{j,t} & \text{with prob} \quad \rho_t, \\ \tilde{z} & \text{with prob} \quad 1-\rho_t, \end{cases}$$

where $\tilde{z} \in \{z_1, \ldots, z_J\}$ is i.i.d. drawn from $\tilde{G}(z)$

- Time-varying turbulence: $1-\rho_t$
  - $\rho_t = 1$: permanent TFP shock
  - $\rho_t = 0$: i.i.d. shock
  - $\rho_t \downarrow \Rightarrow$ high-(low-) productivity firm less likely to remain productive (unproductive) $\Rightarrow$ increased churn in productivity ranking $\Rightarrow$ turbulence $\uparrow$

- $\rho_t =$ Spearman rank corr of firm TFP b/n t and $t+1$

Turbulence is countercyclical



- Turbulence measured by $1 - \rho_t$, where ρ_t is Spearman corr of firm-level TFP b/n year t and $t + 1$, constructed based on Compustat and NBER-CES: $tfp_{ijt} = y_{ijt} - \alpha_{it} k_{ijt} - (1 - \alpha_{it}) n_{ijt}$

Reallocation effects of turbulence

- Estimate the regression:

$$x_{jt} = \beta_0 + \beta_1 High\_TFP_{jt} + \beta_2 Turb_t * High\_TFP_{jt} + \mu_j + \eta_t + \epsilon_{jt},$$

1. x_{jt}: YoY growth of employment, capital, value-added, or market value of firm j in year t
2. $High\_TFP_{jt} = 1$ if firm TFP above median
3. $Turb_t$: turbulence measured by $1 - \rho_t$
4. μ_j and η_t: firm fixed effects and year fixed effects

- Parameter of interest: β_2 captures marginal effects of turbulence on high-productivity firms
  - If $\beta_2 < 0$: stronger adverse effects on high-productivity firms

Turbulence has significant reallocation effects

Dep. Var.	Δn_{jt}	Δk_{jt}	Δy_{jt}	Δv_{jt}
	(1)	(2)	(3)	(4)
$High\_TFP_{jt}$	0.051**	0.124***	0.275***	0.228***
	(0.014)	(0.033)	(0.023)	(0.025)
$Turb_t * High\_TFP_{jt}$	-1.088***	-1.648***	-1.737***	-1.466***
	(0.128)	(0.219)	(0.180)	(0.180)
constant	0.072***	0.093***	0.033***	0.041***
	(0.008)	(0.013)	(0.007)	(0.007)
Firm Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	20,931	20,861	20,624	20,426

- One std increase in turbulence reduces high-productivity firm employment growth by about 15% and capital growth by 9.7%
- Results are robust to using alternative high-TFP indicators

Financial frictions amply reallocation effects of turbulence

- Estimate the industry-level panel regression:

$$x_{it} = \beta_0 + \beta_1 High\_FF_{it} + \beta_2 Turb_t * High\_FF_{it} + \mu_i + \eta_t + \epsilon_{it},$$

1. x_{it}: IQR of employment (or capital) in industry i and year t;
2. $High\_FF_{it} = 1$ iff industry's external financing dependence (KZ index) above median
3. μ_i and η_t: industry and year fixed effects

- β_2: marginal effects of turbulence on industries with high financing dependence (high KZ)
  - Reallocation ⇒ turbulence reduces IQR of N and K
  - If $\beta_2 < 0$: stronger reallocation effects for high-KZ industries

Financial frictions significantly amplify reallocation

Dep. Var.	IQR of Employment		IQR of Capital	
	(1)	(2)	(3)	(4)
$High\_FF_{it}$	0.932***	1.039***	0.959***	1.144***
	(0.288)	(0.278)	(0.320)	(0.319)
$Turb_t * High\_FF_{it}$	-8.201***	-9.486***	-9.428***	-11.222***
	(2.602)	(2.540)	(2.957)	(2.905)
constant	2.162***	2.193***	2.545***	2.573***
	(0.037)	(0.037)	(0.045)	(0.044)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	4,575	4,472	4,575	4,472

- Column (2): lagged dummy $High\_FF_{it-1}$ replacing $High\_FF_{it}$

Macro effects of turbulence

- Local projections (Jorda, 2005)

$$x_{t+h} - x_{t-1} = \beta_0^h + \beta_1^h turb_t + \beta_2^h turb_{t-1} + \beta_3^h \Delta x_{t-1} + \epsilon_{t+h},$$

- x_t denotes macro variable of interest (log level of GDP, C, I, H, firm value, and TFP); $turb_t$ denotes turbulence in log units ($log(1-\rho_t)$)
- β_1^h measures IRFs to turbulence shock at horizon h (years)
- Sample: annual time series from 1958 to 2015

Turbulence generates recession

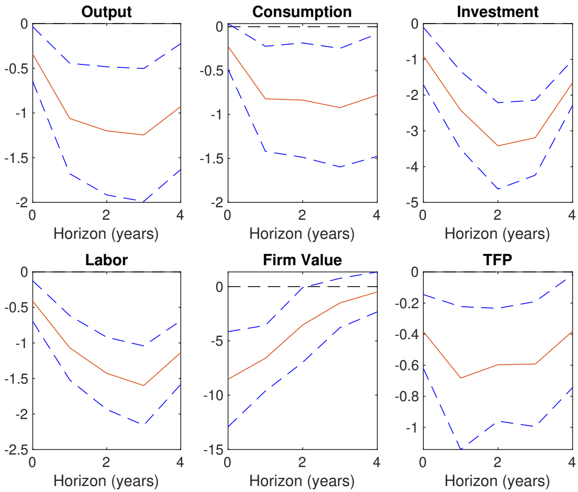


Figure: One standard deviation turbulence shock reduces real GDP by about 0.5%: turbulence quantitatively important

Summary of evidence

- Turbulence rises in recessions
- Increase in turbulence associated with
  1. reallocation from high- to low-productivity firms
  2. reallocation amplified by financial frictions
  3. synchronized and persistent declines in aggregate activity
- Turbulence is quantitatively important: one std increase in turbulence reduces real GDP by 0.5%

RBC model with turbulence shocks

- Heterogeneous firms facing idiosyncratic productivity
- Financial frictions: Firms finance working capital against expected equity value (Jermann-Quadrini 2012; Lian-Ma, 2021)
- Misallocation channel of turbulence
  - Turbulence $\uparrow \Rightarrow$ expected value of high-productivity firms $\downarrow$
  - Tightened borrowing constraints for high-productivity firms $\Rightarrow$ reallocation toward low-productivity firms $\Rightarrow$ TFP $\downarrow \Rightarrow$ recession

Firms

- Production function

$$y_{jt} = A_t z_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha} \tag{1}$$

- Idiosyncratic productivity z_{jt} follows process

$$z_{j,t+1} = \begin{cases} z_{jt} & \text{with prob} \quad \rho_t, \\ \tilde{z} & \text{with prob} \quad 1-\rho_t, \end{cases} \tag{2}$$

where ρ_t is turbulence shock

- Bellman equation:

$$V_t(z_{jt}, \tau_{jt}) = \max_{k_{jt}, n_{jt}} \tau_{jt} A_t z_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha} - R_t k_{jt} - W_t n_{jt} + \mathbb{E} M_{t+1} V_{t+1}(z_{jt+1}, \tau_{jt+1})$$

s.t.

$$R_t k_{jt} + W_t n_{jt} \leq \theta \mathbb{E} M_{t+1} V_{t+1}(z_{jt+1}, \tau_{jt+1}) \equiv \theta B_{jt} \tag{3}$$

where $\tau_j \sim F(\tau)$: i.i.d. distortion (Hsieh-Klenow 2009; Buera-Shin 2013)

Production decisions

- At each productivity z_{jt}, firms are active iff $\tau_{jt} \geq \tau^*_{jt}$
- Break-even threshold

$$\tau^*_{jt} = \frac{R_t^{\alpha} W_t^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha} A_t z_{jt}} \tag{4}$$

- Labor demand

$$n_t(z_{jt}, \tau_{jt}) = \begin{cases} \frac{(1-\alpha)\theta B_{jt}}{W_t}, & \textit{if} \quad \tau_{jt} \geq \tau^*_{jt} \\ 0, & \textit{otherwise} \end{cases} \tag{5}$$

- Capital demand

$$k_t(z_{jt}, \tau_{jt}) = \begin{cases} \frac{\alpha\theta B_{jt}}{R_t}, & \textit{if} \quad \tau_{jt} \geq \tau^*_{jt} \\ 0, & \textit{otherwise} \end{cases} \tag{6}$$

Household optimization and market clearing

- Household's problem:

$$\max_{C_t, N_t, K_{t+1}} \mathbf{E} \sum_{t=0}^{\infty} \beta^t \left\{ \ln C_t - \psi \frac{N_t^{1+\gamma}}{1+\gamma} \right\} \tag{7}$$

  - s.t. budget constraint

$$C_t + K_{t+1} = (R_t + 1 - \delta) K_t + W_t N_t + D_t + T_t \tag{8}$$

- Factor market clearing

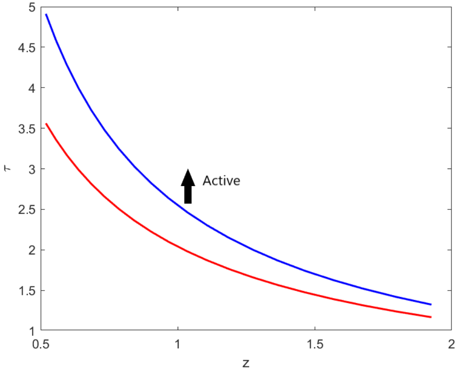
$$N_t = \sum_j \pi_j n_{jt} \equiv \sum_j \pi_j \frac{(1-\alpha)\theta B_{jt}}{W_t} \left[1 - F(\tau_{jt}^*) \right] \tag{9}$$

$$K_t = \sum_j \pi_j k_{jt} \equiv \sum_j \pi_j \frac{\alpha \theta B_{jt}}{R_t} \left[1 - F(\tau_{jt}^*) \right] \tag{10}$$

- Goods market clearing

$$Y_t = C_t + K_{t+1} - (1-\delta) K_t \tag{11}$$

Production decisions



- Active firms: $\{\tau, z\}$ above threshold curve $\tau^*_{jt} \propto \frac{R_t^{\alpha} W_t^{1-\alpha}}{A_t z_{jt}}$
- Turbulence $\uparrow$: high z firms less likely to remain productive $\Rightarrow$ $B_{h,t} \downarrow \Rightarrow W_t,\ R_t \downarrow \Rightarrow$ threshold curve $\downarrow$ and flatter

Misallocation effect of turbulence in steady state

Proposition 1

Given the steady-state factor prices R and W, an increase in average turbulence reduces the share of labor hours allocated to high-productivity firms.

$$\frac{\partial \eta_{ji}}{\partial \bar{\rho}} > 0,$$

where $\eta_{ji} \equiv \frac{N_j}{N_i}$ denotes relative labor hours allocated to firms with $z_j > z_i$.

- Given R and W, turbulence reduces equity value of high-z firms, reallocating N to low-z firms
- GE effects depend on R and W

Calibration

- Turbulence shock $1 - \rho_t$
  - Calibrated based on Spearman correlation of firm-level TFP in annual data 1960-2015, converted to quarterly
  - TFP in data is revenue based, corres. to $TFP_{jt} = z_{jt}\tau_{jt}$ in model
  - τ_{jt} is i.i.d. $\Rightarrow$ Spearman correlation of true productivity z_{jt} same as that of TFP_{jt}
- Idiosyncratic production distortion τ_{jt}
  - Average dispersion $\sigma_\tau = 0.6$ to match IQR of employment (17) in 1960-2015 data
  - Mean value of normalized such that $\mathbb{E}\tau_{jt} = 1$
- Calibrate process for z_{jt} based on $tfp_{jt} = \log(z_{jt}) + \log(\tau_{jt})$
  - Measured TFP has std $\sigma_{tfp} = 0.607$
  - $\log(z_{jt})$ and $\log(\tau_{jt})$ independent $\Rightarrow \sigma_z = \sqrt{\sigma_{tfp}^2 - \sigma_\tau^2} = 0.05$

Calibrated parameters

	Parameter Description	Value	Target
β	Discount factor	0.99	Annual real rate of 4% per year
α	Capital share	0.34	Ave. cost share of capital
δ	Capital depreciation rate	0.025	Annual depreciation rate of 10%
γ	Inverse Frisch elasticity	5	Frisch elasticity of 0.2
θ	Loan to value ratio	0.35	Working K to equity (Compustat)
$\bar{\rho}$	Ave persistence	0.974	Compustat and NBER-CES
ρ_ρ	AR(1) of turbulence	0.882	Compustat and NBER-CES
σ_ρ	std of turbulence shock	0.124	Compustat and NBER-CES
μ_τ	Average distortion	-0.18	Compustat and NBER-CES
σ_τ	std of distortion	0.60	Compustat and NBER-CES
σ_z	std of firm-level TFP	0.05	Compustat and NBER-CES

Macro and reallocation effects of turbulence

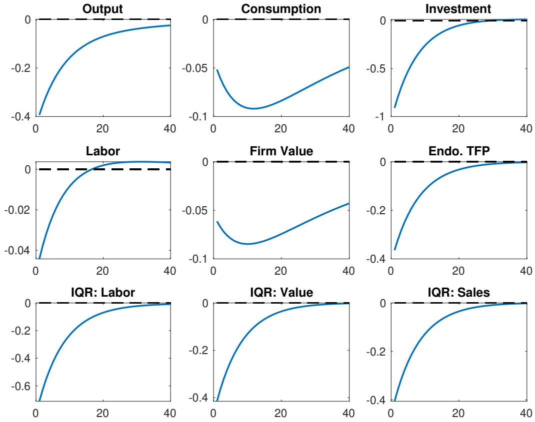


Figure: Impulse responses to one std turbulence shock

Financial frictions important for amplifying turbulence

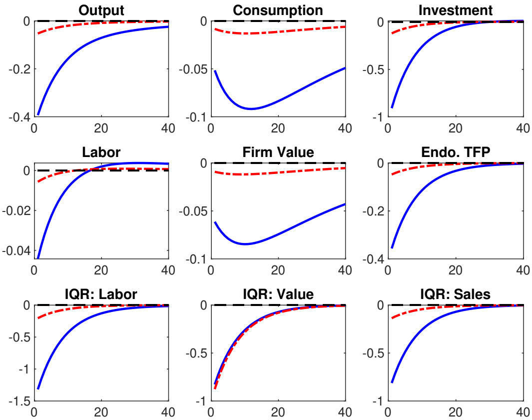
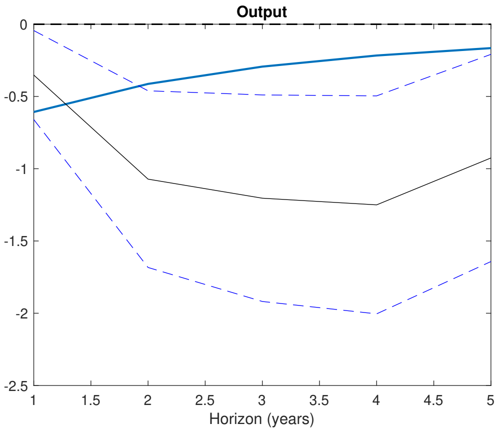


Figure: Counterfactual: "Quasi-fixed" borrowing limit (red lines)

$$R_t k_{jt} + W_t n_{jt} \leq \theta E_t M_{t+1} [\rho_t \bar{V}_j^{ss} + (1 - \rho_t) \sum_{i=1}^{J} \pi_i \bar{V}_i^{ss}]$$

IRF to turbulence shock: Model vs. data



One std turbulence shock reduces aggregate output by about 0.5%, both in data (black line) and in calibrated annual model (blue line)

Turbulence vs micro-level uncertainty

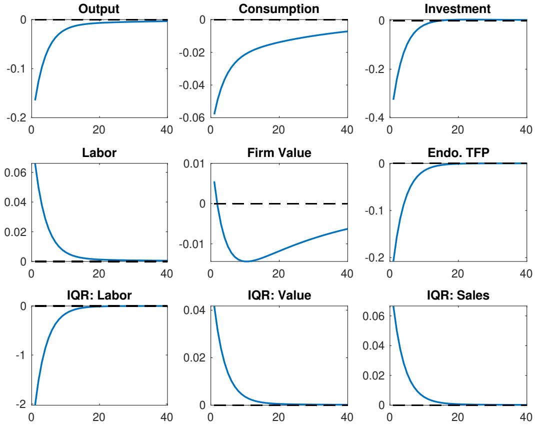
- Micro-level uncertainty shock: mean-preserving spread of idiosyncratic subsidies τ_{jt}

$$\ln(\sigma_{\tau,t}) = (1-\rho_\sigma)\ln(\sigma_\tau) + \rho_\sigma \ln(\sigma_{\tau,t-1}) + \sigma_\sigma \varepsilon_t^\sigma,$$

- Turbulence vs. uncertainty

Shock	Turbulence		Uncertainty	
Firm TFP	(High)	(Low)	(High)	(Low)
Con. Variance	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$
Uncon. Variance	$--$	$--$	$\uparrow$	$\uparrow$
Con. Mean	$\downarrow$	$\uparrow$	$--$	$--$
Uncon. Mean	$--$	$--$	$--$	$--$

IRFs to uncertainty shock



- More low-z firms become active $\Rightarrow$ TFP $\downarrow$ $\Rightarrow$ Y, C, I $\downarrow$
- Each active low-z firm receives less subsidy, $\Rightarrow$ sales IQR $\uparrow$
- Uncertainty boosts labor hours: no macro comovement

Two types of policy interventions

- Policy I: Borrowing subsidy

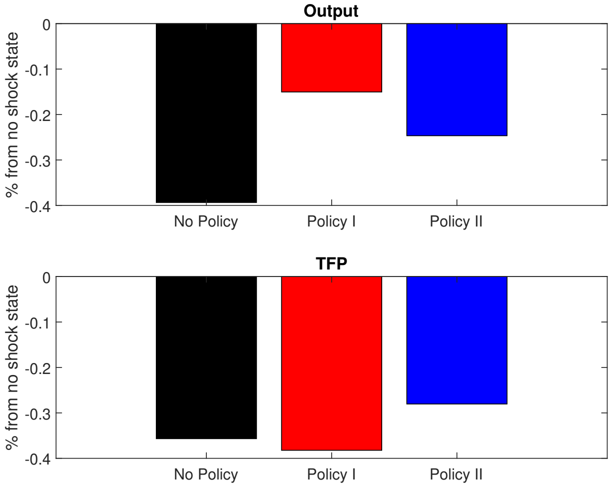
$$s.t. \quad (1-\omega_{1t})(R_t k_{jt} + W_t n_{jt}) \leq \theta B_{jt} \tag{12}$$

- Policy II: Credit easing

$$s.t. \quad R_t k_{jt} + W_t n_{jt} \leq \theta(1+\omega_{2t}) B_{jt} \tag{13}$$

- Both policies incur resource costs (gov't inefficiency); both financed by lump-sum taxes
- Policy interventions triggered by turbulence shock, with same persistence as shock

Stabilizing effects of policy interventions



- Both policies effective for stabilizing output fluctuations
- Borrowing subsidy exacerbates misallocation; credit easing improves it

Conclusion

- Firm-level evidence shows that countercyclical turbulence has important macro and reallocation effects
  - Financial frictions amplify reallocation effects of turbulence
- RBC model with firm heterogeneity and financial frictions highlights reallocation channel of turbulence shocks
- Credit policies can stabilize turbulence-drive recessions, but implications for reallocation and aggregate productivity depend on policy
  - Borrowing subsidies amplify misallocation whereas credit easing mitigates it.