Aggregate-Demand Amplification of Supply Disruptions: The Entry-Exit Multiplier

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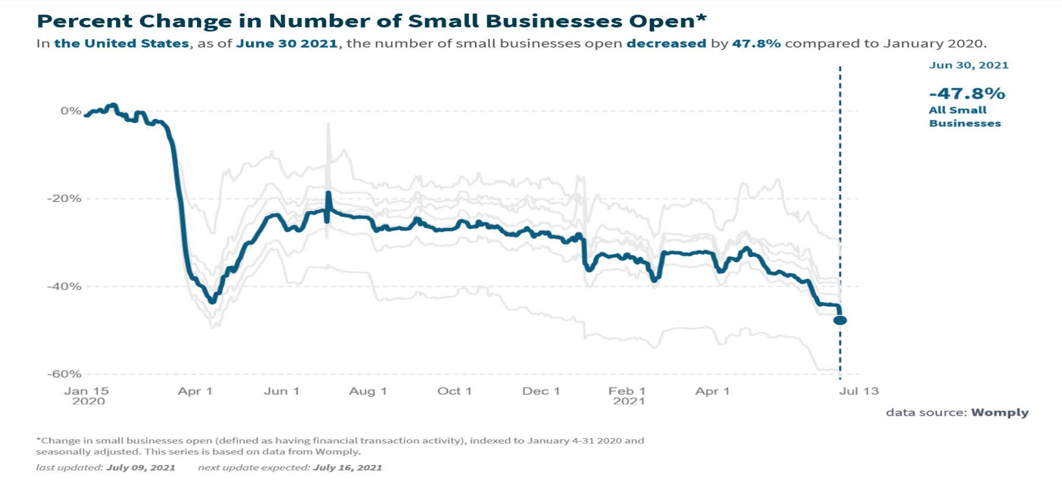
De Nederlandsche Bank
Annual Research Conference
November 5, 2021

Motivation

- When/how do nominal rigidities **amplify** supply disruptions (negative supply shocks)?
  - Inherent feature of business cycle model with **Endogenous Entry-Exit & Variety**
  - Holds in simplest, pared-down model
- Key intuition: Sticky prices distort the extensive margin too
- Application to COVID-19 shock
  - Large protracted recession (~12.5%), **negative output gap**
  - **Exit: 40%** small businesses *closed* Spring 2020, **48%** still closed
    Chetty et al - Opportunity Insights; Crane et al; Kalemli-Ozcan et al

Exit (***Closures***: *Chetty et al, Opportunity Insights*)



*Similar: *Homebase* data (Crane et al); estimated exit rate <u>doubled</u> (Kalemli-Ozcan et al) Results

This Paper

1. **Entry-Exit Multiplier**: Sticky Ps amplify **Agg.-Supply** (TFP) shocks response

$$\text{Multiplier} = \theta > 1 \text{ (Elasticity of Substitution/Demand).}$$

[1]+ Complete markets! (Representative agent).

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2. Aggregate-Demand **Amplification** of Aggregate supply disruption $da < 0$

Effect of TFP **decrease** on Y (*absolute value*)			Y *Gap*
	Flexible Prices	**Sticky Prices**	
No Entry-Exit[1]	1	≤ 1	≥ 0
Endog. Entry-Exit	x > 1	X(da) > x	< 0

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3. **Bonus**: entry-exit → hours' TFP response **NK~RBC**!

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Literature

- **Entry-Exit & Variety: Business Cycles** (2000s)
  - Bilbiie Ghironi Melitz (2012 JPE); Jaimovich Floetotto; Colciago Etro; Lewis Poilly; Clementi Pallazzo; Lee Mukoyama; Dixon Savagar; Cacciatore Fiori; Hamano Zanetti; Edmond Midrigan Xu; Sedlacek Sterk; Gutierrez Philippon; Carvalho Grassi; Michelacci Paciello Pozzi; **90s**: Chatterjee Cooper; Devereux Head Lapham; Cook; Kim
- **Entry-Exit & Variety w/ Nominal Rigidities: Monetary Policy**
  - Bilbiie Ghironi Melitz (2007 NBER MA); Bergin Corsetti, Bilbiie Fujiwara Ghironi; Etro Rossi; Bilbiie (2019), Cacciatore Fiori Ghironi; Colciago Silvestrini, Hamano Zanetti, ...
- **COVID-19 Recession:**
  - Guerrieri Lorenzoni Straub Werning; Woodford; Baqaee Farhi; Fornaro Wolf; Basu et al; Auerbach et al; Cesa-Bianchi Ferrero
  - different: **aggregate** supply shock (TFP) + **endogenous** entry-exit, GE intensive+**extensive**→aggregate C; **complementary**: goods (*disaggregated*) vs sectors
- **TFP & hours: NK vs RBC**
  - Galí; Chari Kehoe McGrattan; Basu Fernald Kimball; Christiano Eichenbaum Vigfusson; Alexopoulos; Galí Rabanal; Peersman Straub; Foroni Furlanetto Lepetit; Cantore Leon-Ledesma McAdam Willman

Endogenous Entry-Exit NK Model: Simplest, Static

- **CES** $Y_t = \left(\int_0^{N_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}}, \theta > 1$ ES across ω

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- Simplest AD, static; **money** $M_t = P_t Y_t$ (generalize to Euler eq + Taylor rule)

The Entry-Exit Multiplier

- **Proposition: The Entry-Exit Multiplier**

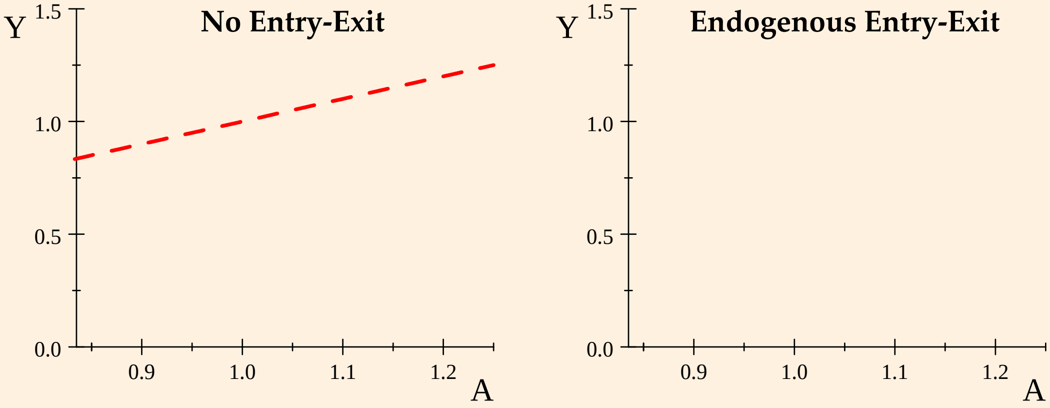
$$N_t^{EF} = \frac{1}{\theta}\frac{A_t \bar{L}}{f} \qquad \text{vs} \qquad N_t^{ES} = \frac{A_t \bar{L}}{f} - \frac{M_t}{f\bar{p}}$$

$$\implies \frac{d\log N_t^{ES}}{d\log A_t} > \frac{d\log N_t^{EF}}{d\log A_t}$$

- Intuition: $A \downarrow$; F: prices $\uparrow$ & exit, **both** intensive & extensive
- S: stuck with too low $p \rightarrow$ loss $\rightarrow$ exit $\rightarrow$ endog. "productivity" (variety) $\downarrow$
  - adjustment disproportionately born by **extensive** margin
  - Firms too few & large = distortion
- more plausible for **negative** (large) shocks; inability to $\uparrow$ p in slump
- sticky p: Reduced form friction ~inability to contract despite loss→exit

The Entry-Exit Multiplier –> AD Amplification?

Mind the nonlinearity!



Y^F (flex. prices) red dash, Y^S (sticky prices) solid blue

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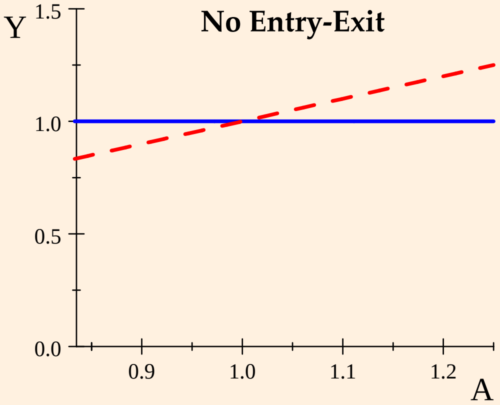

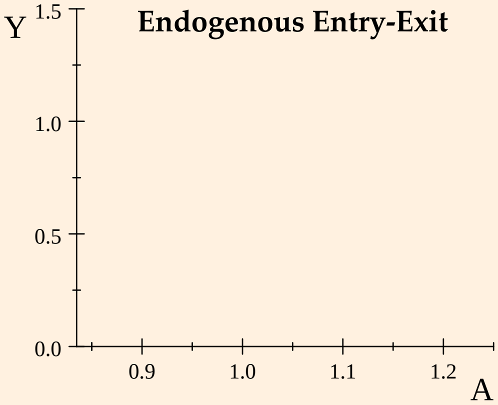

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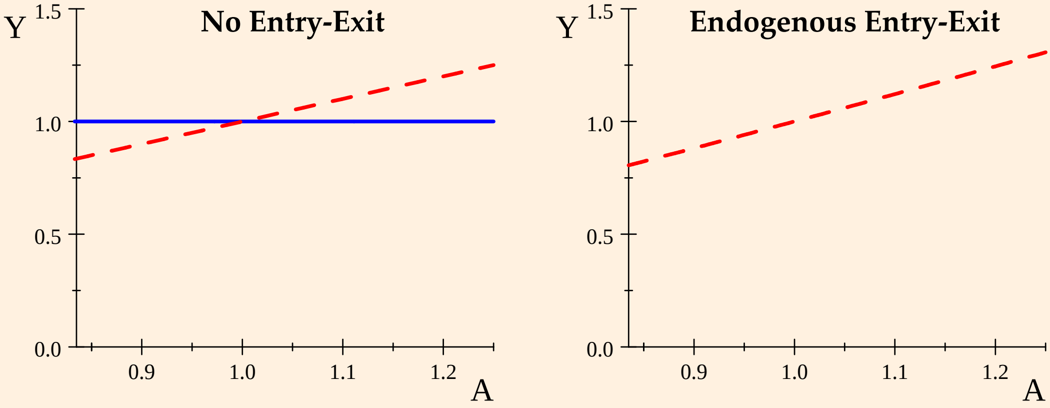

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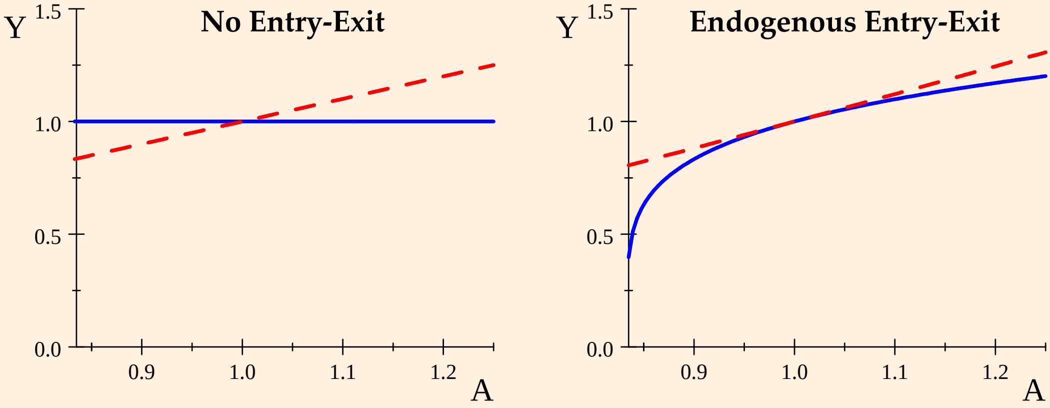

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The Entry-Exit Multiplier –> AD Amplification?

Proposition To 2nd order (x log-dev. of X):

$$y_t^{EF} \simeq \frac{\theta}{\theta - 1} a_t + \frac{1}{2} \frac{\theta}{(\theta - 1)^2} a_t^2$$

$$y_t^{ES} \simeq \frac{\theta}{\theta - 1} a_t + \frac{1}{2} \frac{\theta^2 (2 - \theta)}{(\theta - 1)^2} a_t^2$$

$$\rightarrow \text{Output gap: } y_t^{ES} - y_t^{EF} \simeq -\frac{1}{2} \theta a_t^2$$

- **Always negative** (Second-order): $\downarrow$ more w/ $A \downarrow$.
- Large **negative** shocks $\rightarrow$ S response much larger.
- First-order **identical** (neutrality proposition Bilbiie, 2019)

The Entry-Exit Multiplier –> AD Amplification?

- **Key:** $Y(N)$ nonlinear, amplifies A higher-order (N linear in A)

$$Y_t = N_t^{\frac{\theta}{\theta-1}} \left(\frac{A_t \bar{L}}{N_t} - f \right) \rightarrow y_t \simeq -\frac{1}{2} \frac{\theta}{(\theta-1)^2} n_t^2$$

- N amplification to (negative) $A \rightarrow Y$ amplification by concavity
- decreasing with benefit of input variety $\frac{1}{\underline{\theta}-1}$
- crucial for extensive vs intensive, distorted w/ sticky p
- more intensive desirable but unfeasible, *less* important w/ closer substitutes:
  - θ larger, less benefit of variety, less distortion.
- θ determines **both** entry-exit multiplier & concavity, opposite effect
- Net effect of θ = **amplify gap** (disentangle later)

Quantitative (Nonlinear) Model

- Rotemberg pricing, ψ adjustment cost param. $C_t = (1 - \frac{\psi}{2}\pi_t^2) Y_t$:

$$(1+\pi_t)\pi_t = \beta E_t[(\frac{C_t}{C_{t+1}})^{\frac{1}{\sigma}} \frac{N_t}{N_{t+1}} \frac{Y_{t+1}}{Y_t}(1+\pi_{t+1})\pi_{t+1}] + \frac{\theta}{\psi}[\frac{1}{\mu_t} - \frac{\theta-1}{\theta}(1 - \frac{\psi}{2}\pi_t^2)]$$

- $1+\pi_t \equiv p_t/p_{t-1}$ and $1+\pi_{C,t} \equiv P_t/P_{t-1}$:

$$\frac{1+\pi_t}{1+\pi_{C,t}} = \left(\frac{N_t}{N_{t-1}}\right)^{\frac{1}{\theta-1}}.$$

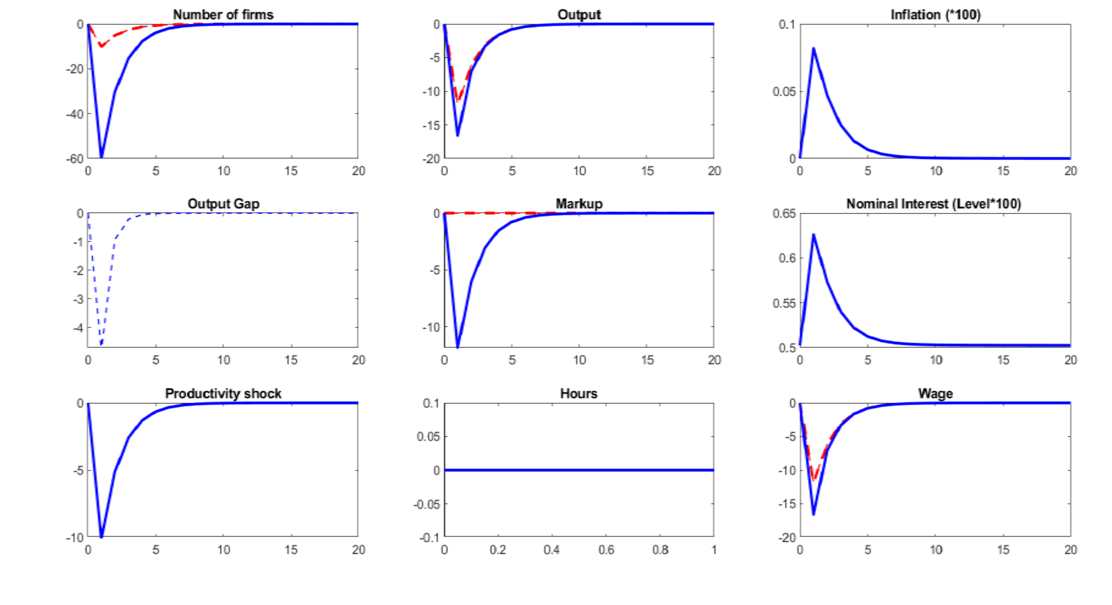
- AD relevant: CPI π_t^C $\rightarrow$ intertemp. subst. Euler:

$$C_t^{-\frac{1}{\sigma}} = \beta E_t \left(\frac{1+I_t}{1+\pi_{C,t+1}} C_{t+1}^{-\frac{1}{\sigma}}\right).$$

$$1 + I_t = \beta^{-1}(1+\pi_t)^{\phi}$$

- Param.: $U = \ln C - .5L^2$, CES $\theta = 3.8$, PC slope ~0.01; $\phi = 1.5$, A persist. .5

Quantitative (Nonlinear) Model



Flexible (red dash) and Sticky (solid blue) prices.

Bonus: Entry Solves NK-RBC Hours Controversy

- known controversy: hours countercyclical wrt TFP shocks in NK
- RBC: opposite, and indeed central ingredient
- NK + **Entry-Exit** → convergence
  - NK response driven by income effect of profits. Entry-exit eliminates that
- Best illustrated w/ GHH preferences (η inverse labor elasticity)

$$l_t^{NF} = \eta^{-1} a_t \neq l_t^{NS} = -\theta a_t$$

$$l_t^{EF} = l_t^{ES} = \frac{\theta}{\eta(\theta - 1) - 1} a_t$$

Same response (with CES)

First-order AD Amplification w/ Entry-Exit Multiplier

- External returns $Y_t = N_t^{\lambda} \times CES; \rho_t = N_t^{\lambda + \frac{1}{\theta - 1}}, \lambda > 0$
- Planner $N_t^{opt} / N_t^{EF} = 1 + \lambda (\theta - 1) / \left(\lambda + \frac{\theta}{\theta - 1} \right) \rightarrow$ **too little** entry when $\lambda > 0$
- **Key: Entry-Exit Multiplier + Inefficiency –> AD amplification**

$$y_t^{ES} - y_t^{EF} = \lambda (\theta - 1) a_t + \frac{1}{2} \left(\lambda + \frac{1}{\theta - 1} \right) \left[\lambda \left(\theta^2 - 1 \right) + \theta - \theta^2 \right] a_t^2$$

$$y_t \simeq \lambda n_t + \frac{1}{2} \left(\lambda + \frac{1}{\theta - 1} \right) \left(\lambda - \frac{\theta}{\theta - 1} \right) n_t^2.$$

  – $\lambda > 0 \Leftrightarrow \frac{dY}{dN} > 0$: higher "indirect effect" of A on Y through N
  – disentangle benefit of input variety $\lambda + \frac{1}{\theta - 1}$ & elast. subst. θ for curvature

- $\rightarrow$ **3-Equation NK model w/ Entry-Exit** (textbook-isomorphic): see paper

Intertemporal vs Inter-good Substitution: CRRA utility

- C CES aggregate, labor inelastic (*general: paper*)

$$U(C) = \frac{C^{1-\frac{1}{\sigma}} - 1}{1 - \frac{1}{\sigma}}$$

  $\ln C_t$ limit as $\sigma \to 1$

- σ elasticity of *intertemporal* substitution

Intertemporal vs Inter-good Substitution: CRRA utility

- Entry-exit multiplier

$$n_t^{ES} = \frac{\theta}{\sigma} a_t = \frac{\theta}{\sigma} n_t^{EF}.$$

- Output gap (first-order zero, CES envelope):

$$y_t^{ES} - y_t^{EF} \simeq -\frac{1}{2}\left(\frac{\theta}{\sigma} - 1\right)\frac{\theta}{\theta - 1} a_t^2.$$

Both entry-exit multiplier *and* AD amplification condition (restriction w/ lnC):

$$\underbrace{\theta}_{\in[4,8]} > \underbrace{\sigma}_{\in[0,2]} \Leftrightarrow \underline{\text{substitutability}}$$

- Guerrieri Lorenzoni Straub Werning: (looks) **opposite! is it**?
- **Complementary** mechanisms, coexist & reinforce each other:
  - here, disaggregated (goods) subst., GLSW aggregate, sectoral-level complementarity

Conclusion

- *A simple theory of supply-driven demand shortages*
  1. **Entry-Exit Multiplier** (of Supply Shocks) w/ Sticky prices
  2. **Aggregate Demand** amplification (curvature, inefficiency w/ ext. returns)
- **Plausible** condition: more willing to *substitute* between goods than over time
- Solves an **NK-RBC controversy**: same-sign hours response to TFP
- **Stabilization policy** *implication*: subsidize entry/prevent exit
- **Follow-up** work: persistence, hysteresis, heterogeneity.

Intertemporal vs Inter-good Substitution: CRRA utility

- Nutshell: extensive N vs intensive y

$$Y = \rho N y = N^{\frac{\theta}{\theta-1}} y$$

- *individual* demand, intensive margin Euler *exogenous* extensive margin:

$$y_{\omega t} = E_t y_{\omega t+1} - \left(1 - \frac{\sigma}{\theta}\right) \frac{\theta}{\theta - 1} \left(n_t - E_t n_{t+1}\right) - \sigma \left(i_t - E_t \pi_{t+1}\right)$$

Exogenous exit $dn_t < 0 \rightarrow$ demand for continuing goods $\downarrow$ iff

$$\sigma > \theta \text{ -- Edgeworth } \underline{\text{complementarity}}$$

  - "real"(-PPI) natural rate falls w/ $a_t \downarrow$

$$r_{\omega t}^{EF} \equiv \left(i_t - E_t \pi_{t+1}\right)^{EF} = \left(\frac{1}{\sigma} - \frac{1}{\theta}\right) \frac{\theta}{\theta - 1} \left(E_t a_{t+1} - a_t\right).$$

Intertemporal vs Inter-good Substitution: CRRA utility

- Here: aggregate A + **endogenous** N, GE $\rightarrow$ aggregate Y: N and y
- Aggregate Euler:

$$y_t = E_t y_{t+1} + \frac{\sigma}{\theta - 1}\left(n_t - E_t n_{t+1}\right) - \sigma\left(i_t - E_t \pi_{t+1}\right)$$

  $i_t - E_t \pi_{t+1}$ fixed **but** AD-$r \uparrow$, exit $n_t \downarrow \rightarrow$ int. subst. to future
  - General mechanism, arbitrarily sticky p
- **GE**: CES extensive & intensive cancel out first-order (envelope)
  - AD amplification: *curvature & inefficiency* (external returns)
- **Complementary** mechanisms (coexist and reinforce each other):
  - here, disaggregated (goods), GLSW sectors