Productivity, Demand and Growth

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Motivation: sources of aggregate economic growth

State of the art: aggregate growth driven by firm lifecycle dynamics

- Aggregate growth: R&D, creative destruction, selection, and reallocation
  - → Aghion, Howitt (1992), Klette, Kortum (2004), Acemoglu et al. (2018), Akcigit, Kerr (2018)

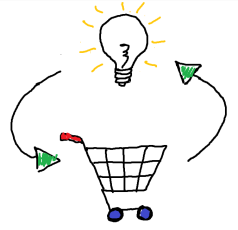
Data: firm selection and growth largely driven by demand side!

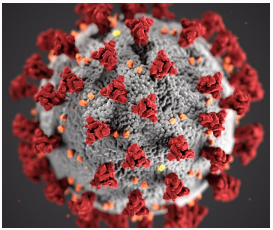
- e.g. Foster et al. (2008), Foster et al. (2016), Hottman et al. (2016), Cavenaile, Roldan-Blanco (forthcoming), Cavenaile et al. (2021), Eslava, Haltiwanger (2021)

This paper brings frictional demand into an endogenous growth model

- firms invest into R&D to raise own productivity
- AND invest into increasing demand for own products

Main idea in pictures - demand spurring innovation





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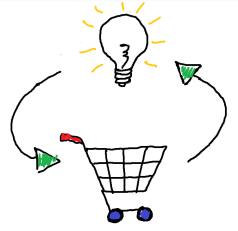
Main idea in pictures - innovation creating demand



Our contribution

Firm lifecycle dynamics driven by more than just productivity

- Add to the empirical results on interactions between market size, and firm-level R&D
  - $\rightarrow$ Fiscal policy shocks as an instrument, study firm-level R&D over firm lifecycle

Build endogenous growth model with frictional customer base accumulation

- analytically show new channel affecting R&D decisions
- **feedback loop between customer base and productivity at the firm-level**

Quantitative results show that the customer base accumulation

- drives 20% of aggregate economic growth
- is the key determinant of the sensitivity of the economy to growth policies

Roadmap

Theoretical framework

Quantitative Results

- Firm-level outcomes
- Aggregate growth
- Sensitivity to growth policies

Empirical Support for Key Model Predictions

Conclusion

Representative household: max lifetime utility s.t. budget

- consumes composite good (price $P = 1$), investments (firm equity), and supplies inelastically labor

$$C = \left[\int_{j \in \Omega} b_j^{\frac{1}{\eta}} c_j^{\frac{\eta-1}{\eta}} dj \right]^{\frac{\eta}{\eta-1}}$$

  - $\rightarrow$ Ω_j: mass of firms (set of goods), η: elasticity of substitution between varieties
  - $\rightarrow$ c_j: quantity of consumption variety produced by firm j
  - $\rightarrow$ b_j: "demand shifter (weight)" or tastes for good j

Optimal decisions:

$$c_j = b_j p_j^{-\eta} C, \qquad 1 = \beta(1 + R') \frac{C}{C'}$$

Firms: Entry/exit, production and R&D as in Akcigit and Kerr (2018)

- Firms produce goods varieties $c_j = q_j n_j$
- Pay fixed operating cost to continue
- Invest into R&D in order to improve q_j, x_j is the success probability

$$\underbrace{s_j}_{\text{researchers}} = \underbrace{(n_j)^{\sigma}}_{\text{production employees}} \times \underbrace{x_j^{\psi}}_{\text{prob. of a success}}, \quad \psi > 1 \text{ and } \sigma > 0,$$

$$v(q_j, b_j) = \max_{p,c,x,b'} \left[\begin{array}{c} p_j c_j - W_t(n_j + s_j) + \\ \frac{1-\delta}{1+R'} \mathbb{E}\left\{ x_j v^+(q_j(1+\lambda), b'_j) + (1-x_j) v^+(q_j, b'_j) \right\} \end{array} \right]$$

Customer capital accumulation as in Foster et al. (2016)

- customer capital: $b_j = \chi d_j^{\gamma}$
- exogenous component: $\ln \chi' = \rho_\theta \ln \chi + \epsilon_j$, $\epsilon_j \sim IID(0, \sigma_\epsilon^2)$
- endogenous component: $\ln d_j' = (1-\zeta) \underbrace{\left[(1-\rho_d) \ln d_j + \pi_j\right]}_{\text{passive changes}} + \underbrace{\zeta \ln \left(\frac{c_j p_j}{C} \right)}_{\text{active changes}}$
- "passive changes" (growing-by-being, age effects)
  - $\rightarrow$ π_j: firm-specific, potentially varying, life-cycle growth factor
- "active changes" (growing-by-doing): **strategic pricing** details

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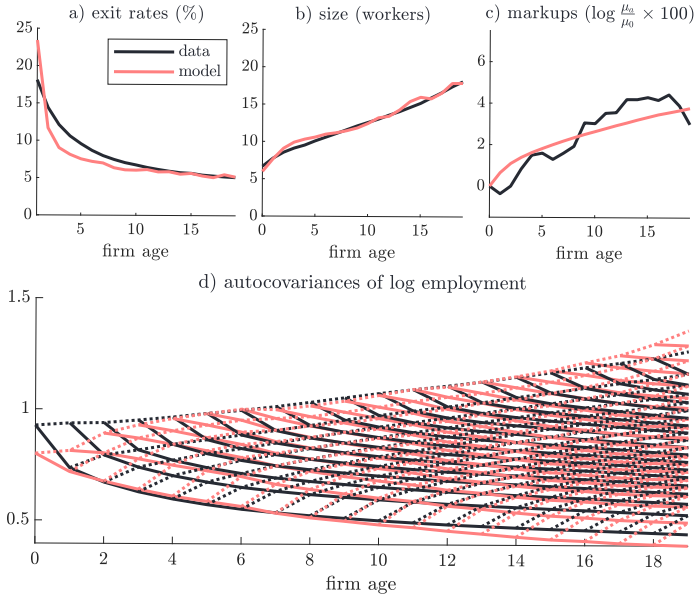
Parametrization strategy: Joint estimation

- Standard choices
  - → step size, λ: aggregate growth (real GDP)
  - → R&D cost elasticity, ψ: empirical studies suggest $\psi = 2$
  - → R&D cost scaling with size, σ: R&D share – firm size (**Compustat**)
- **Key novelty:** separation between productivity and customer capital at the firm-level
  - → optimal pricing implies markup lifecycle profile: ζ (**Compustat**)
  - → match model to estimated profile from firm-level data (**Compustat**)
  - → life-cycle profiles of size, exit and autocovariance structure to discipline remaining shocks (**BDS**)
  - → following Sterk (r) al. (2021)

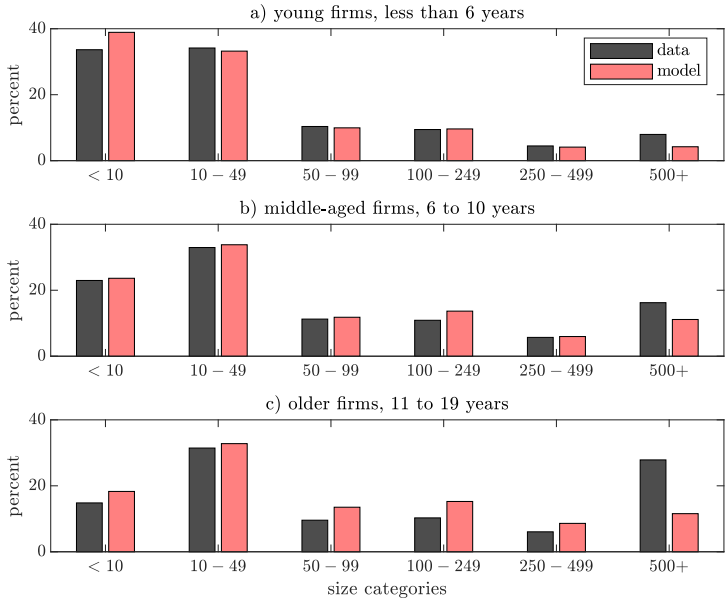
Model fit: targeted moments



Model fit: Other implied moments

	model	data
A: Targeted moments		
aggregate growth	1.45%	1.50%
aggregate R&D-output ratio	2.66%	2.20%
firm-level R&D-size relationship	−0.022	−0.028
B: Untargeted firm dynamics moments		
job creation rate	20%	17%
job destruction rate	20%	15%
job creation share from entry	11%	9%
job destruction share from exit	18%	17%

Model fit: Untargeted firm-size distribution



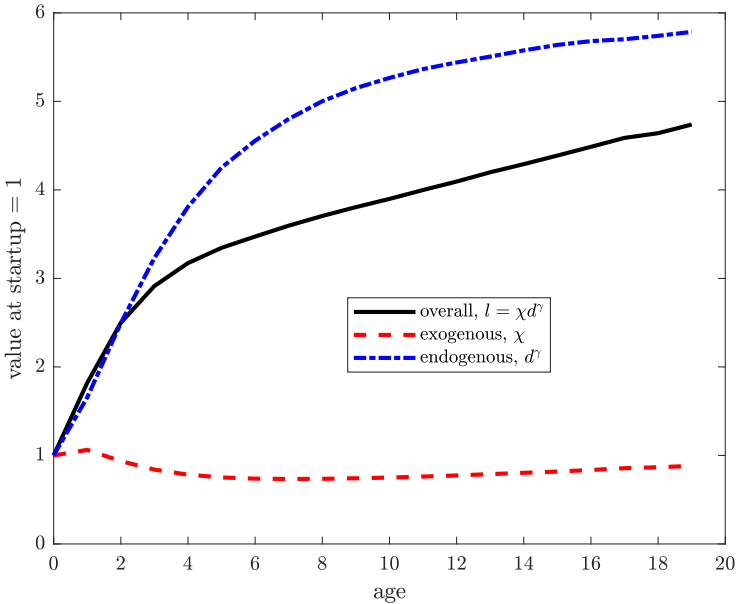
Decomposing baseline results: A counterfactual economy

The key channel operates through expected demand growth at firm-level

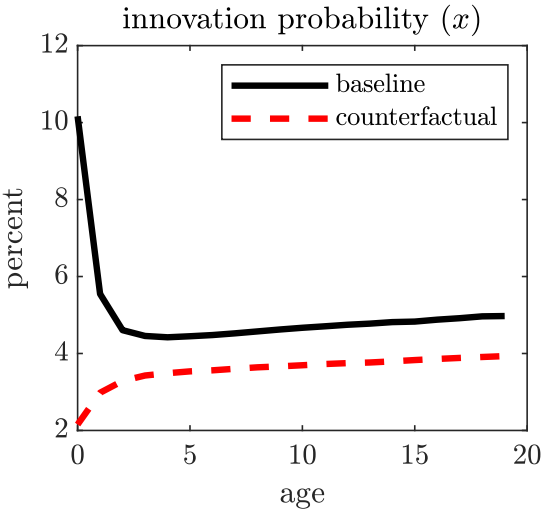
- consider a counterfactual, "fixed-demand", economy
  - → expected demand = today's demand, as in standard growth models
    - separately for passive, passive+active, all (passive+active+exogenous) demand
- otherwise all else equivalent to baseline model, including
  - → *realizations* of demand shocks
  - → equilibrium variables (wages, mass of firms, consumption, growth)

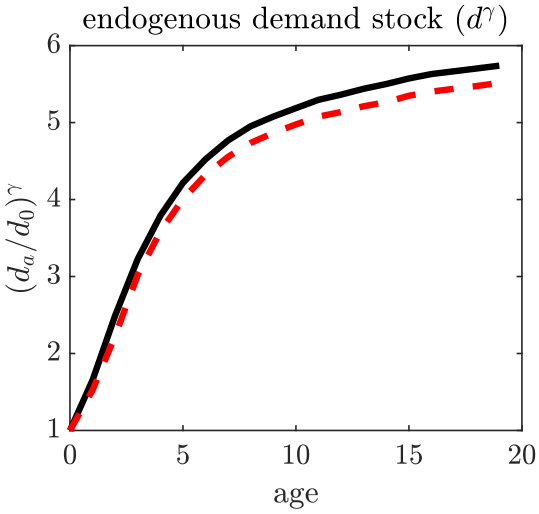
Baseline - counterfactual = (PE) impact of expected demand growth

Demand stock accumulation over firms' life-cycle



Endogenous R&D and demand accumulation at the firm-level





In the presence of customer accumulation, aggregate growth is 20% higher!

Sensitivity to growth policies

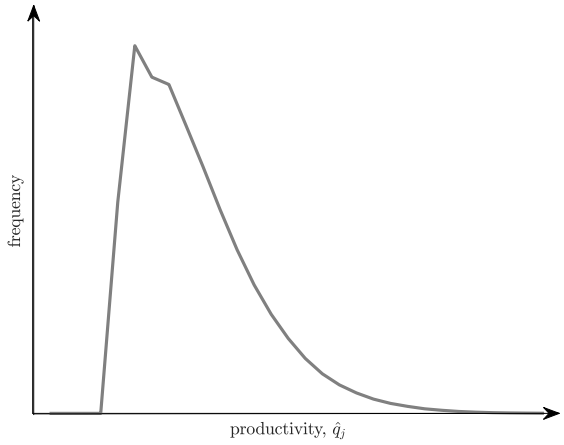
Consider 2 examples of growth policies: (i)subsidize R&D, (ii) subsidize operation

Compare baseline to "productivity-only" model (recalibrated to baseline targets)

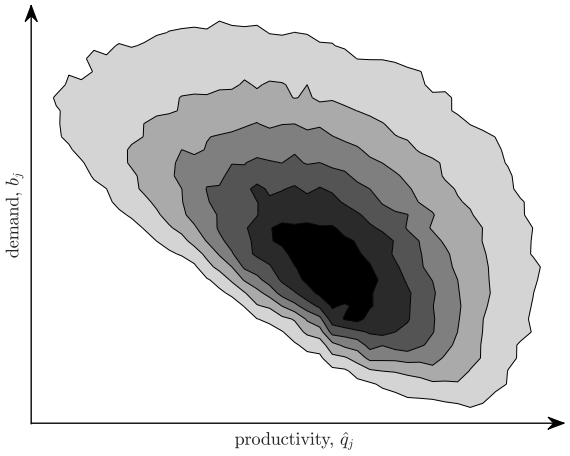
	innovation	firm exit	agg. growth
	A: Operational cost subsidies		
Baseline specification	$+0.55$	-0.33	-0.04
Restricted: Fixed demand stocks	$+0.74$	-1.42	-0.11
	B: R&D subsidies		
Baseline specification	$+0.51$	-0.14	$+0.04$
Restricted: Fixed demand stocks	$+0.86$	$+0.98$	$+0.28$

Customer base and the sensitivity to operation cost subsidies

(A) Restricted model



(B) Baseline model



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Personal income tax cuts (Mertens and Ravn, 2013) as aggregate demand shocks

$$\log\left(\frac{\text{R\&D}_{j,t}}{\text{revenues}_{j,t}}\right) = \delta_j + \delta_t + \hat{g}^{(m)}_{j,t+1} + \hat{g}^{(m)}_{j,t+1} \times \text{age}_{j,t} + X_{i,t} + \eta_{j,t}$$

future revenue growth	0.032***	0.156***
	(0.007)	(0.027)
log age	-0.010***	-0.002
	(0.002)	(0.003)
log age × future revenue growth		-0.052***
		(0.011)
additional controls	✓	✓
Observations	44,432	44,432
Within R^2	0.32	0.32
firm fixed effects	✓	✓
time × industry fixed effects	✓	✓

R&D subsidies across the US states (Wilson, 2009) and firm-level R&D intensity

$$\log\left(\frac{\text{R\&D}_{j,t}}{\text{revenues}_{j,t}}\right) = \tau_{s,t} + \log(\text{age})_{j,t} \times \tau_{s,t} + \log(\mu)_{j,t} \times \tau_{s,t} + X_{j,t} + \delta_j + \delta_s + \delta_t + \epsilon_{j,t}$$

R&D user cost	-0.014	-0.141***	-0.108**
	(0.035)	(0.044)	(0.052)
age × R&D user cost		0.048***	0.047***
		(0.010)	(0.011)
average markup × R&D user cost			-0.050*
			(0.030)
additional controls	✓	✓	✓
firm fixed effects	✓	✓	✓
time × industry fixed effects	✓	✓	✓
state fixed effects	✓	✓	✓

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Summary

Business dynamism driven by demand, not productivity alone

- evidence on interactions between productivity, demand, and firm-level growth
- build endogenous growth model reflecting this
- analytically show how the new channel affects the R&D decisions

Quantitative results show that demand growth is important for

- 20% of aggregate economic growth demand-driven
- a higher sensitivity of the economy to growth policies

We believe our paper opens the door to more research

- new set of growth policies (monetary policy, procurement, transfers)?

Endogenous demand

Optimal markup over marginal costs:

$$\mu_j = \underbrace{\frac{\eta}{\eta-1}}_{\text{static markup}} - \beta(1-\delta)(1-\rho_d)\mathbb{E}\underbrace{\frac{q_j}{q_j'}\frac{c_j'}{c_j}\frac{\varphi_j'}{\varphi_j}\left[\mu_j'(\zeta-1)+\frac{\eta}{\eta-1}-\zeta\right]}_{>0}$$

- firms choose low markups in expectation of high consumption growth
- over lifecycle, gradually increase markups towards static value
- $\rightarrow$ increasing life-cycle profile of markups (controlled by ζ) go back