

Uncertain Innovation and Growth Traps

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How to promote innovation and growth?

- Two types of spillovers from innovation
 - ▶ Knowledge spillovers
 - ▶ Product market spillovers
- Challenge: How can the government support firms that produce the highest net spillovers?
- “The government can’t pick winners”

How to promote innovation and growth?

- Two types of spillovers from innovation
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Claim

- There’s a third spillover from uncertainty
- Picking winners shouldn’t be the goal, the government should actually support losers.

In this paper...

Standard expanding variety framework with two new features:

- (i) Aggregate uncertainty about the returns to R&D
 - ▶ Many factors that affect the returns to R&D are uncertain and correlated between similar firms/sectors.
- (ii) Learning from market outcomes
 - ▶ Firms can learn about these factors by observing the outcomes of other firms, innovation outcomes are noisy signals
 - ▶ New type of spillover

Preliminary findings:

- Emergence of growth traps
- Policy implications may differ from other types of spillovers

The Model

Final Good Production

- Final good production:

$$Y_t = L_t^{1-\alpha} \sum_{j=0}^{M_t} q_{j,t}^{1-\alpha} x_{j,t}^{\alpha}$$

- $x_{j,t}$: Intermediate good j
- $q_{j,t}$: 'Quality' of intermediate good j
- M_t : Measure of intermediate good firms at time t
- L_t : Labor

- Demand for intermediate good j :

$$x_{j,t} = L_t \left(\frac{\alpha}{P_{j,t}} \right)^{\frac{1}{1-\alpha}} q_{j,t}$$

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$$x_{j,t} = L_t \left(\frac{\alpha}{P_{j,t}} \right)^{\frac{1}{1-\alpha}} q_{j,t}$$

- t : Entrants can invest in R&D (η) to invent a new product variety
- $t + 1$: Firms choose prices and production optimally facing demand from the final good producer

- Per-period profit:

$$\pi_{j,t+1} = \bar{\omega} q_{j,t+1} L_{t+1}$$

- q determines how profitable the new product is and is unknown

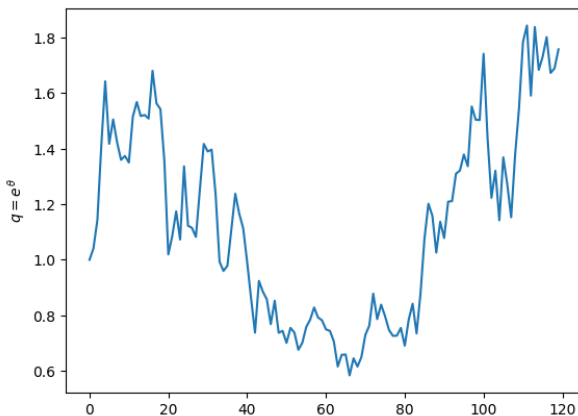
$$q_{t+1} = e^{\theta_{t+1}}$$

$\Rightarrow$ *Aggregate Uncertainty*

Key Assumption I: Uncertainty about the returns to R&D

- θ : uncertain and unobserved factors that affect future profits

$$\theta_t = \rho\theta_{t-1} + \varepsilon_t^\theta, \quad \text{with} \quad \varepsilon_t^\theta \sim N(0, \sigma_\varepsilon^2)$$



Key assumption II: Learning from Market Outcomes

- Firms have prior beliefs: $\theta | \mathcal{I} \sim N(\mu, \gamma^{-1})$
- Innovation attempts of other firms reveal information about θ in form of a signal S :

$$S_t = \theta_t + \varepsilon_t^S, \quad \text{where} \quad \varepsilon_t^S \sim N(0, (f(z_t))^{-1})$$

- The precision of the signal increases in R&D investment (z_t)
 $\Rightarrow$ *Spillover*
- Updating rules:

$$\mu' = \rho \frac{\gamma \mu + z \gamma_S S}{\gamma + z \gamma_S} \quad \gamma' = \left(\frac{\rho^2}{\gamma + z \gamma_S} + (1 - \rho^2) \sigma_\theta^2 \right)^{-1}$$

- Value of investing in R&D:

$$V(\mu_t, \gamma_t) = -\eta + \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} d_{st} \pi(\theta_{t+1}) \middle| \mu_t, \gamma_t \right]$$

- ▶ η : Cost of R&D
- ▶ d_{st} : Stochastic discount factor
- ▶ μ, γ : Mean and precision of firms beliefs about θ

- Free entry condition:

$$z_t > 0 \Leftrightarrow V(\mu_t, \gamma_t) = 0$$

Results

Growth Trap

(i) θ is directly observed $\Rightarrow$ No spillover from learning

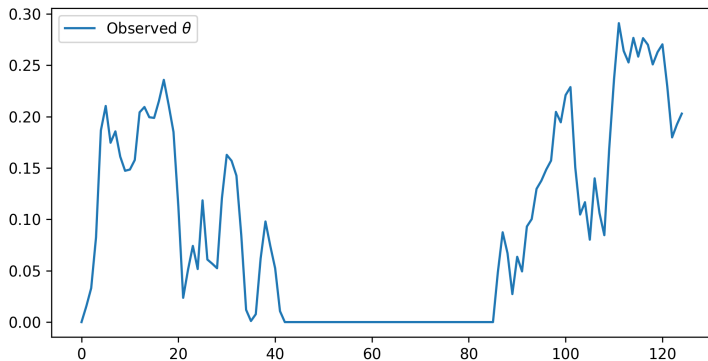


Figure: Growth rate of the economy

Growth Trap

- (i) θ is directly observed $\Rightarrow$ No spillover from learning
- (ii) θ is not observed, and firms learn from noisy signals

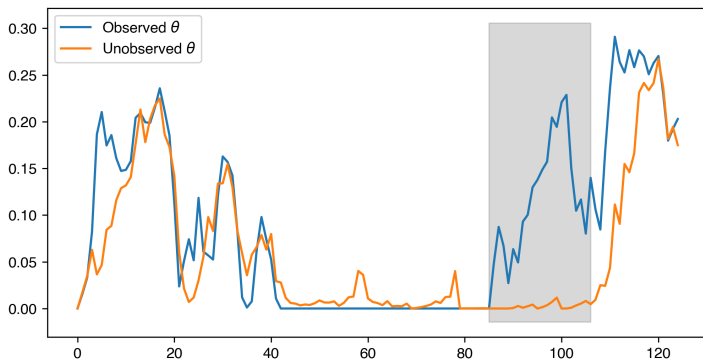


Figure: Growth rate of the economy

Evolution of Beliefs

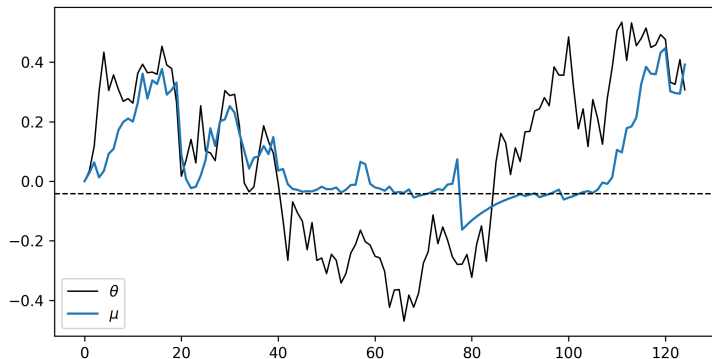
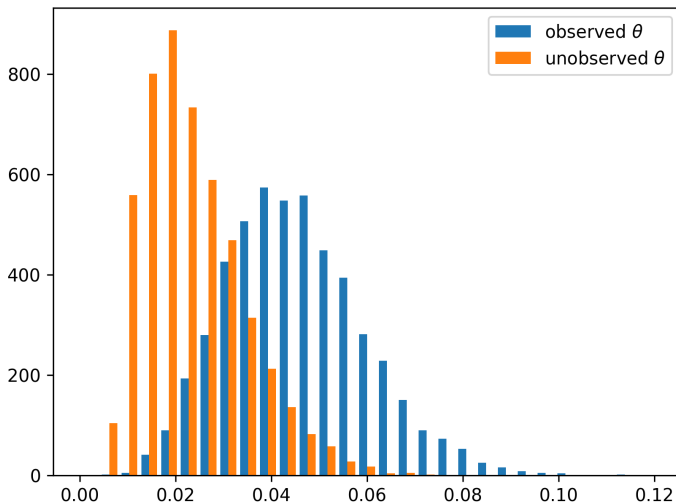


Figure: Evolution of the fundamental variable θ and firms beliefs μ

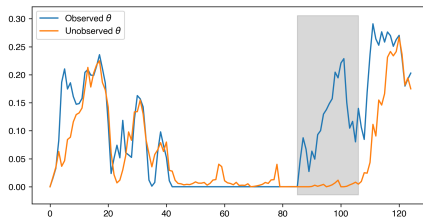
Average growth rates with and without spillovers



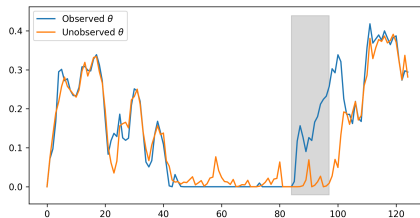
Policy Implications

- Subsidize the cost of R&D: $\hat{\eta} = (1 - \tau)\eta$
- Welfare improvement
 - ▶ θ is observed: 17% Observed θ
 - ▶ θ is unobserved: 40% Unobserved θ
- Welfare improvement of subsidies is higher when there are information spillovers
- Subsidies shorten the growth traps

Shorter Growth Trap with Subsidies



(a) Growth trap without subsidies



(b) Growth trap when R&D is subsidized

Direct Government R&D Investment

Is there a cheaper policy that targets growth traps directly?

(i) Constant R&D investment rate: z^G

Observed θ

Unobserved θ

(ii) Government investment when beliefs are too pessimistic

Fig.

$$z_t^G = \begin{cases} z^G & \text{if } \mu_t < \bar{\mu} \\ 0 & \text{otherwise} \end{cases}$$

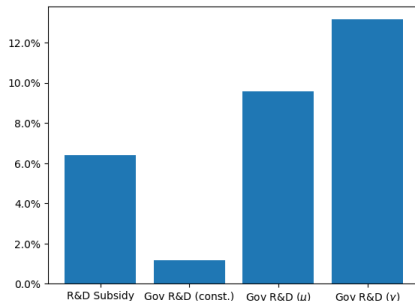
(iii) Government investment when uncertainty is too high

Fig.

$$z_t^G = \begin{cases} z^G & \text{if } \gamma_t < \bar{\gamma} \\ 0 & \text{otherwise} \end{cases}$$

Welfare Improvement of different Policies

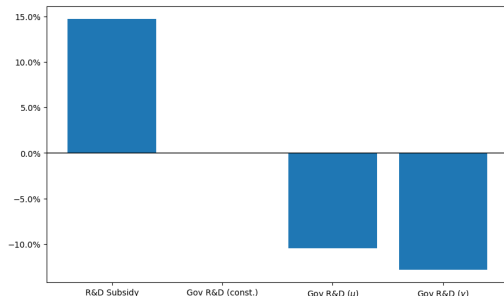
Figure: Increase in permanent consumption per 0.1% of gdp in government funded R&D



- Direct government investment in sectors with high uncertainty might be the most effective policy

Returns to Government R&D

What would the return to governments investment be?



- ⇒ The government R&D projects perform miserably
- ⇒ Spillovers from failed innovation attempts

Conclusion

Expanding variety framework with two new features

1. Aggregate uncertainty
2. Learning from the outcomes of other firms R&D investments
 - Learning from other firms investments creates a spillover
 - Externality leads to the emergence of growth traps
 - The implications for policy may differ from other spillovers

What I plan to do next:

- *Derive optimal policy, think about observable variables governments can use to target potential growth traps*
- *Multiple sectors and calibration*

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Appendix

1 Growth Effects of Business Cycle Shocks

Comin and Gertler (2006); Queralto (2020); Anzoategui et al. (2019); Benigno and Fornaro (2018); Fajgelbaum et al. (2017);

- ▶ Shocks can have long-lasting effects on growth

2 Spillovers and Policy Implications

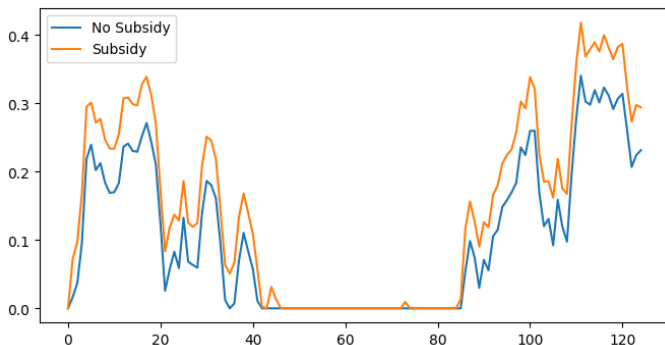
Atkeson and Burstein (2019); Akcigit et al. (2022); Bloom et al. (2019)

- ▶ Introduce a new type of spillover
- ▶ Show how this spillover may have different implications for policy

3 Effect of Uncertainty on (R&D) Investment

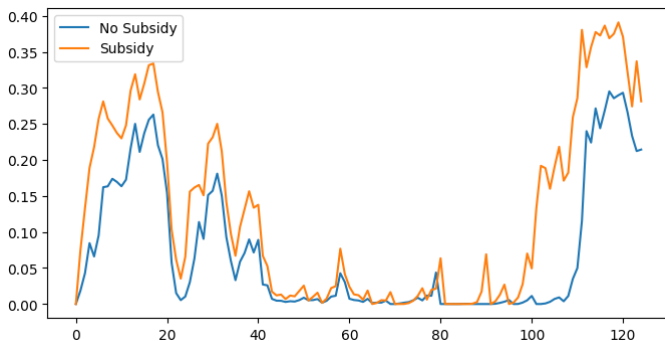
Bloom (2007); Bloom et al. (2022); Vo and Le (2017); Czarnitzki and Toole (2011)

Effect of R&D subsidies when θ is observed



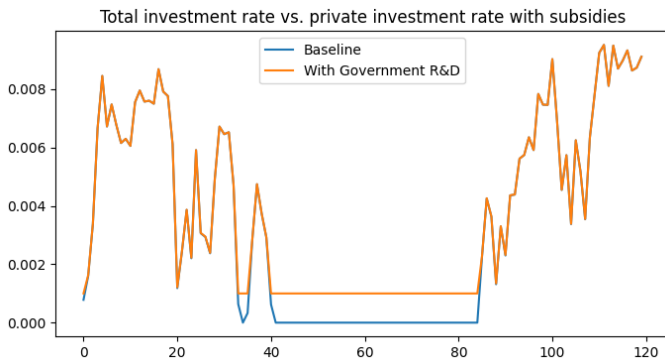
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Effect of R&D subsidies when θ is unobserved



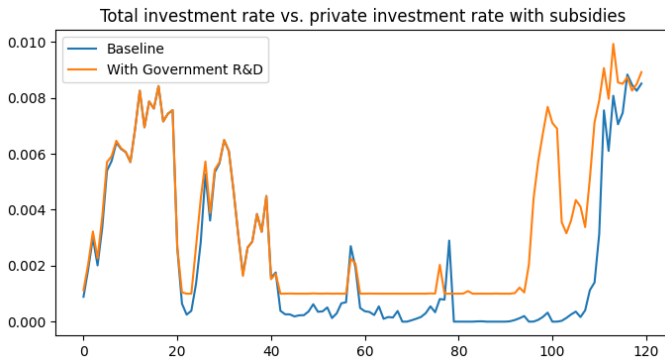
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Constant government R&D when θ is observed



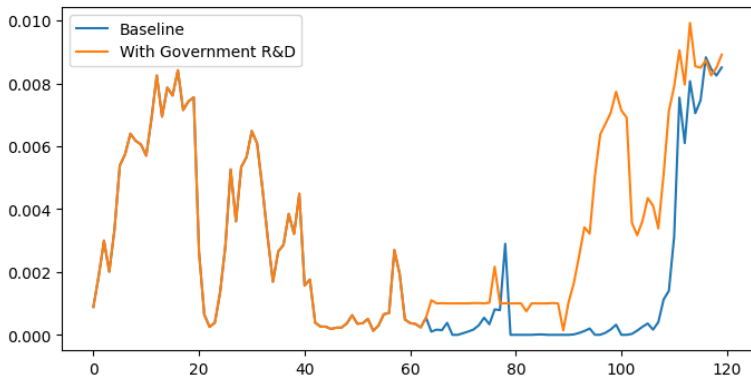
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Constant government R&D when θ is unobserved



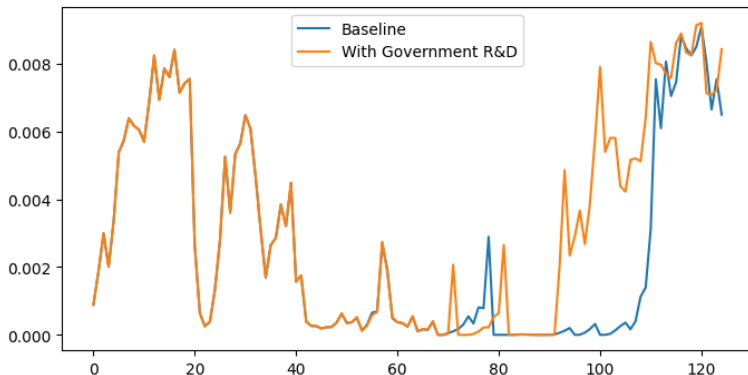
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Direct government R&D when beliefs are too pessimistic



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Direct government R&D when uncertainty is too high



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Relationship between Uncertainty and R&D

The relationship between uncertainty and R&D is unclear both theoretically ...

- Wait-and-See dynamics: firms reduce irreversible investments when uncertainty is high
- Growth options: uncertainty increases investment when there is limited downside risk

... and empirically

- Negative impact of uncertainty on R&D:
Czarnitzki and Toole (2011); Arif Khan et al. (2020)
- Positive impact of uncertainty on R&D:
Stein and Stone (2013); Tajaddini and Gholipour (2020); Vo and Le (2017)

Relationship between Uncertainty and R&D

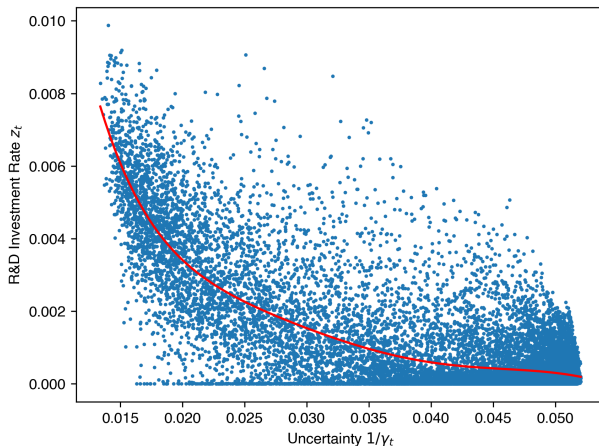


Figure: Relationship between R&D Investment and Uncertainty today

Relationship between Uncertainty and R&D

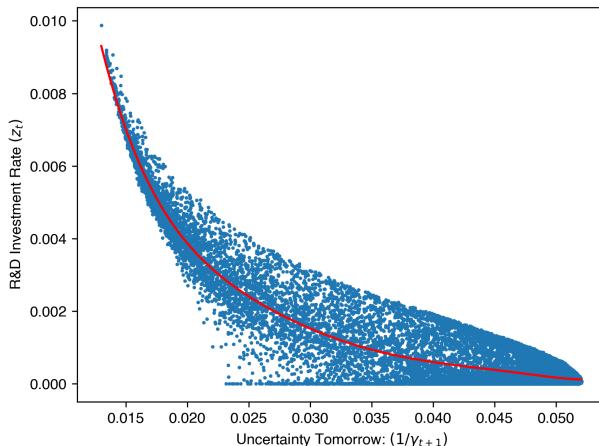


Figure: Relationship between R&D Investment and Uncertainty tomorrow

Parameter used for simulation

	Value	Description
α	0.1	Parameter of the production function
β	0.95	Households discount rate
σ	2	Coefficient of relative risk aversion
ρ	0.9	Persistence of the AR(1) process for θ
σ_θ	0.229	Standard deviation of the ergodic distribution of θ
η	0.05	Cost of R&D
γ_S	200	Scale parameter for precision of signals